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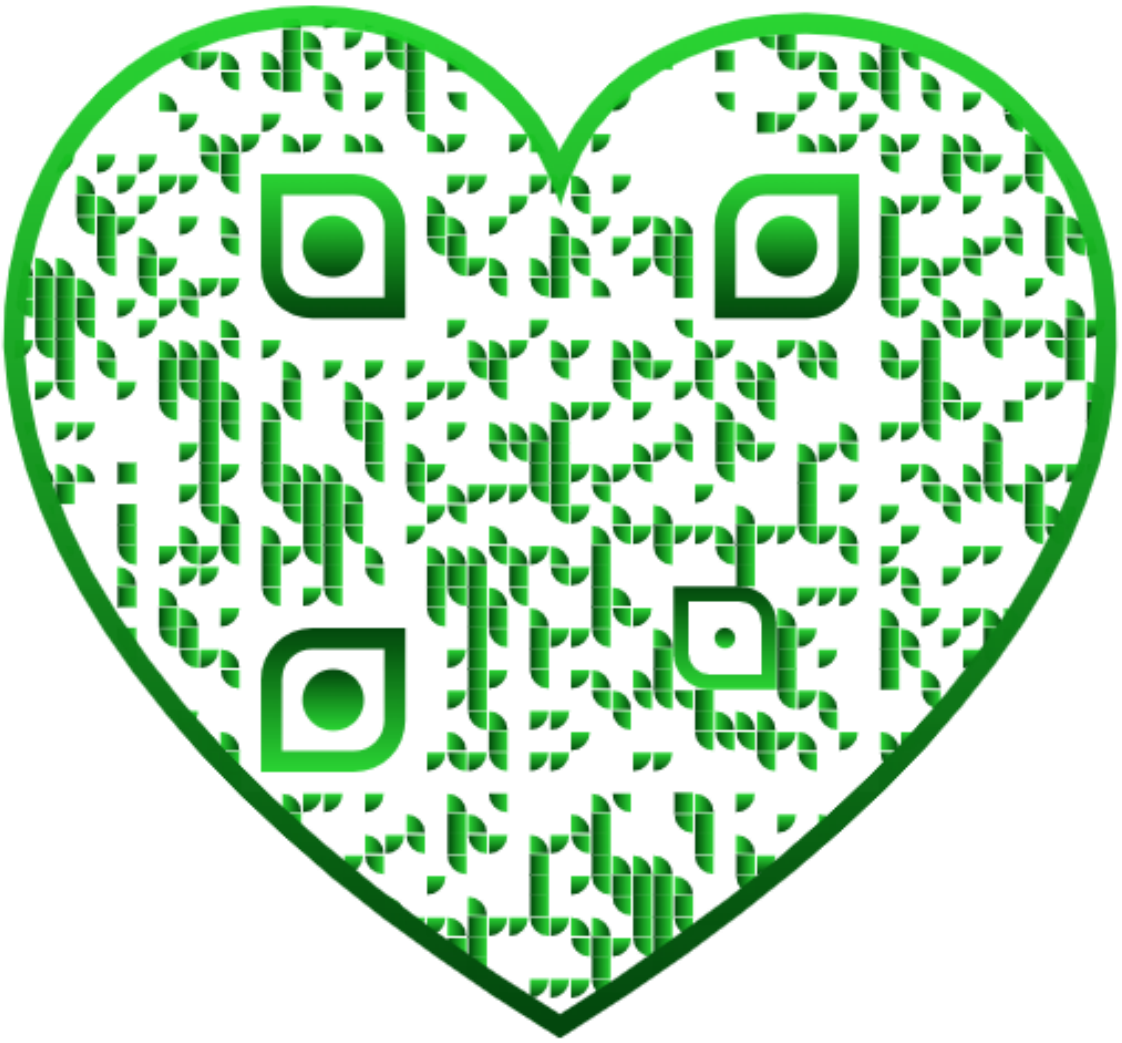

This book is dedicated to my family, who has always supported me through my academic endeavors. Without their support, the successes that I have achieved today would not have been possible. I would like to thank them all starting with my wife and followed by my children:

Dr. Chhaya

Dr. Abdulkhalique

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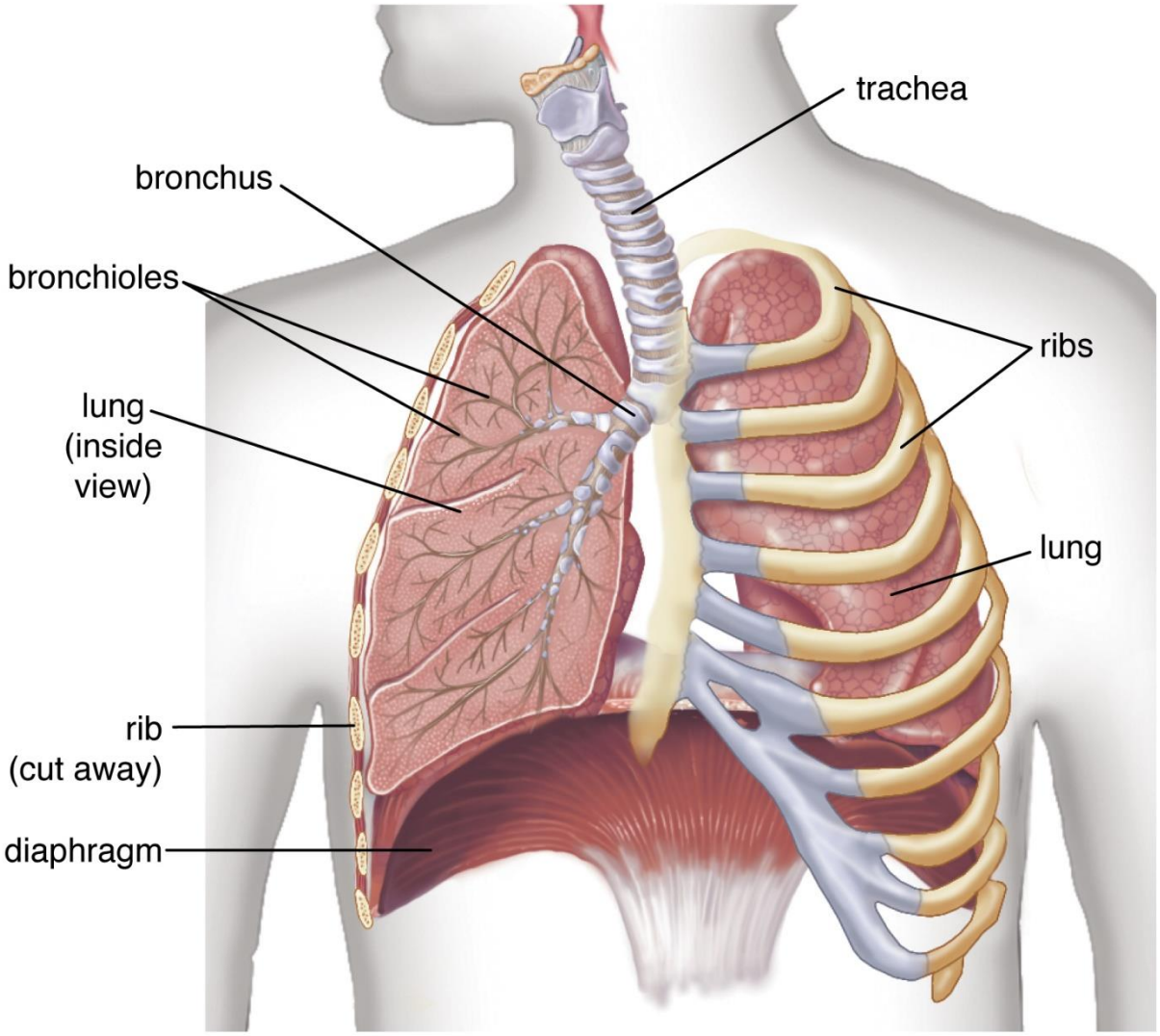
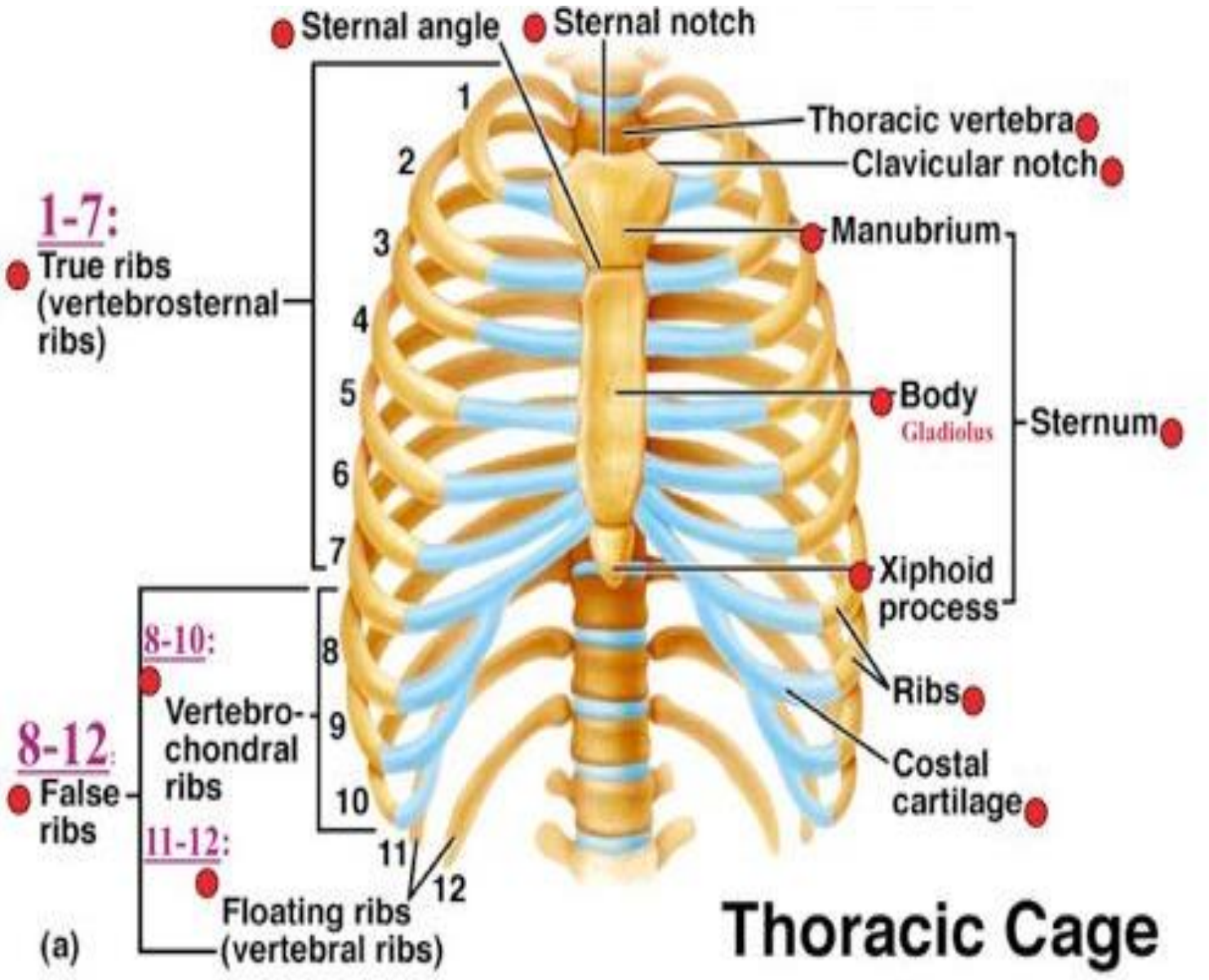
Noor Ahmed Alzuabidi | **Reem Abdulmajeed Alyousefi**

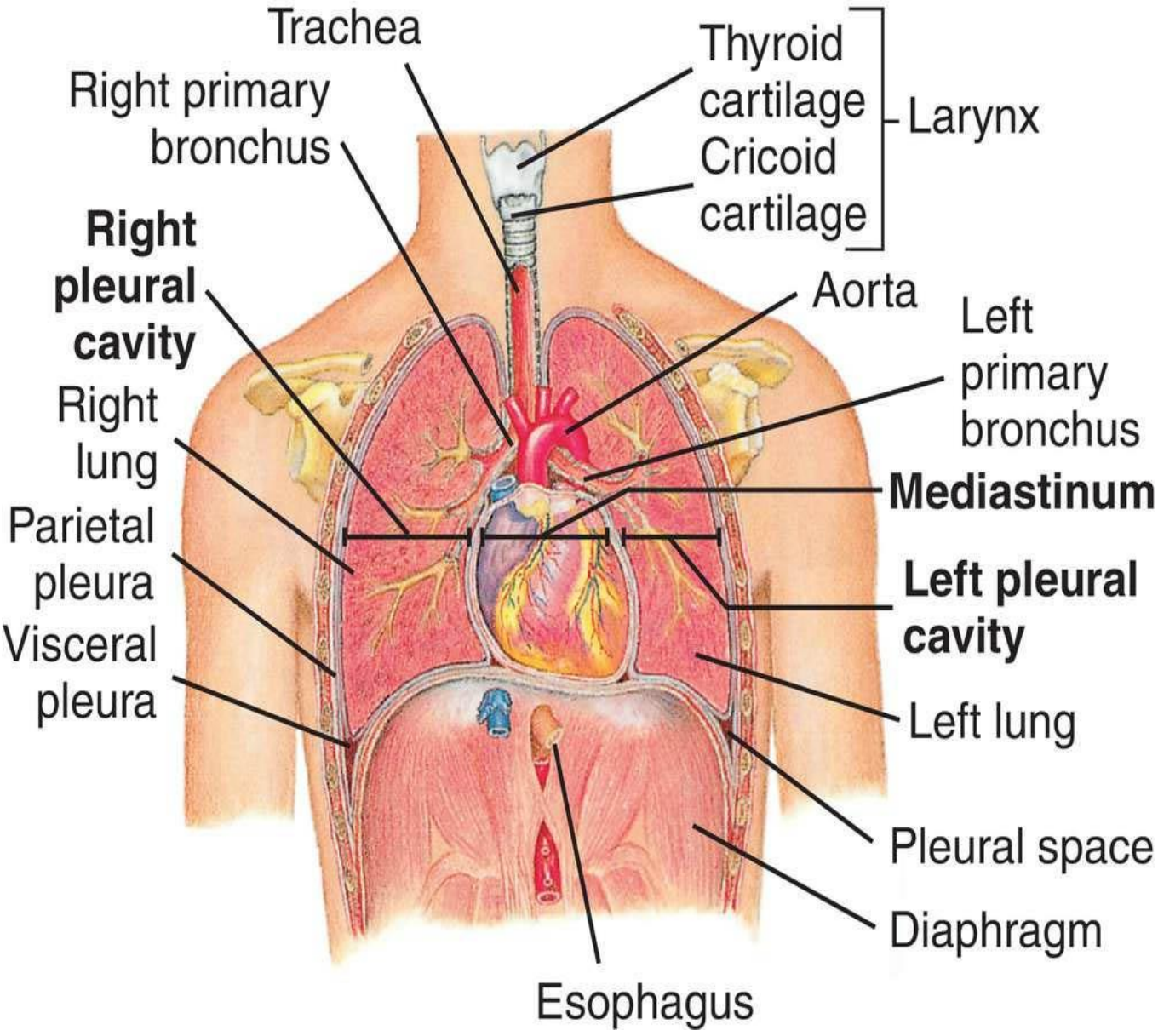
Thorax

- **Definition:** its an irregular shaped cylinder.
  - **Superiorly:** a narrow opening called the Superior Thoracic Aperture (or inlet)
  - **Inferiorly:** a relatively large opening called the Inferior Thoracic Aperture (or outlet)
- The superior thoracic aperture is an opening that allows continuity with the neck.
- The inferior thoracic aperture is closed by the diaphragm.



Thoracic Cavity



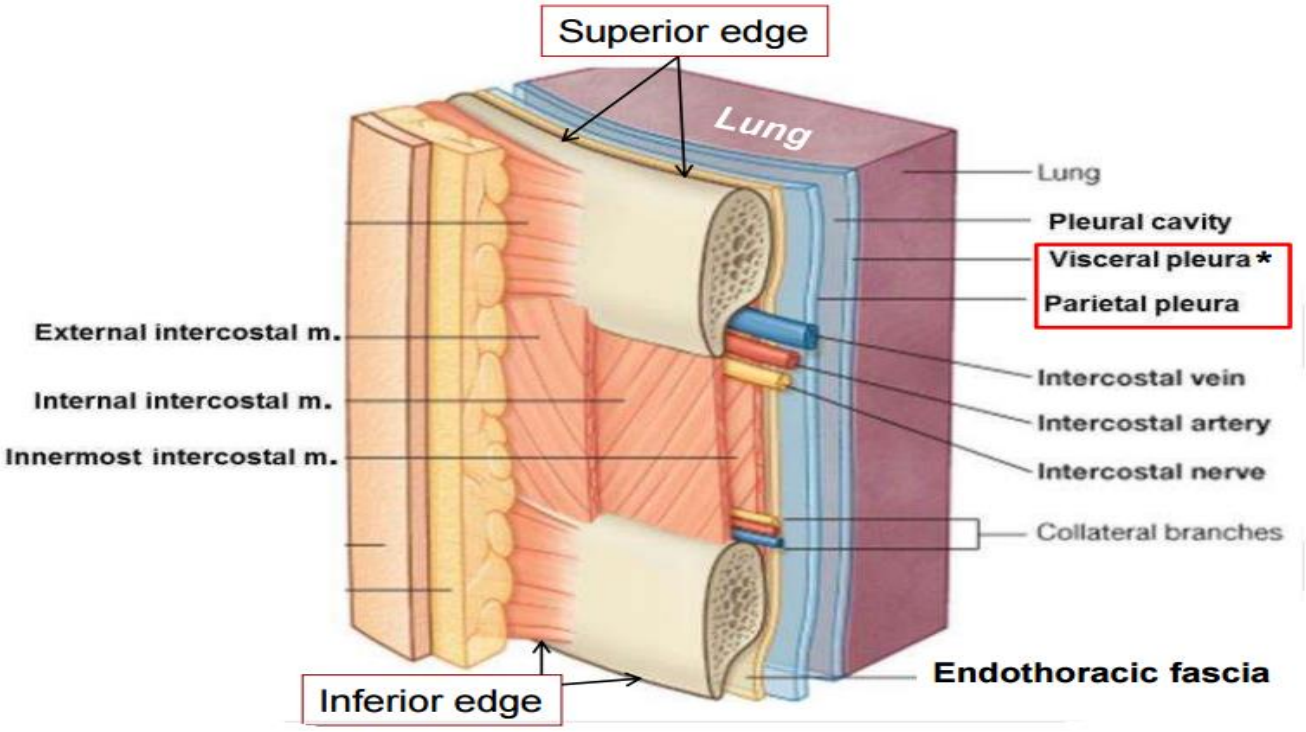


- **Definition:** it's the cavity which is enclosed by thoracic wall and diaphragm. It is subdivided into three major compartments:
    - Left Pleural cavity surrounds the left lung
    - Right Pleural cavity surrounds the right lung
    - Mediastinum
        - **Note:** The mediastinum is a thick midline partition that extends from the sternum anteriorly to the thoracic vertebrae posteriorly, and from the superior thoracic aperture to the inferior thoracic aperture.

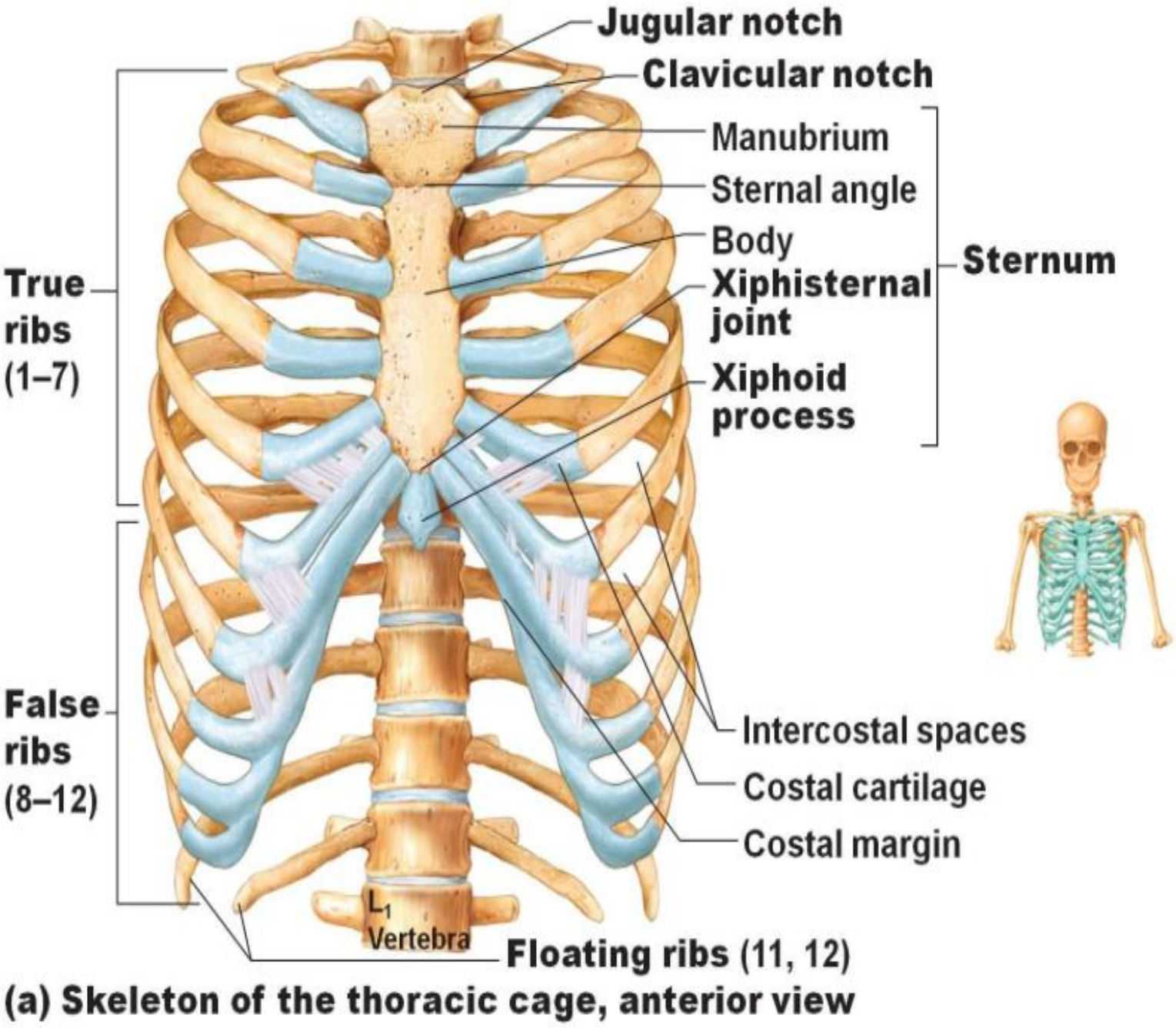
- **Function of the Thoracic Cavity:**
  - **Breathing:**
    - One of the most important functions of the thorax is breathing. The thorax not only contains the lungs but also provides the machinery necessary: the diaphragm, thoracic wall and ribs. All of which are needed to effectively move air into and out of the lungs.
  - **Protection of Vital Organs:**
    - The thorax houses and protects the heart, lungs, great vessels, and abdominal viscera due to the domed shape of diaphragm.
      - **Example:** muscles of liver, stomach, and spleen.
  - **Conduit:**
    - The mediastinum acts as a conduit for structures that pas completely through the thorax from one body region to another and for structures that connects organs in the thorax to other body regions.
      1. The Esophagus
      2. Vagus Nerves
      3. Thoracic duct pass through the mediastinum as the course between the abdomen and the neck.
      4. Phrenic nerves
      5. Trachea
      6. Thoracic Aorta
      7. Superior Vena Cava
  - **Divisions of the Thoracic Cavity:**
    - **Pleural Cavities:**
      - One on each side containing a lung
    - **The Mediastinum:**
      - it's the middle space left in the thoracic cavity between the lungs, that contains a number of structures.
        - The Mediastinum is divided into:
          - Superior Mediastinum
          - Inferior Mediastinum—which is further divided into:
            - Anterior Mediastinum
            - Posterior Mediastinum
            - Middle Mediastinum
- **Note:** the endothoracic fascia lines the thoracic cavity.

Endothoracic Fascia

- **Definition:** It's a loose fibro-cellular tissue, deep to the intercostal spaces and ribs. Separating them from the pleura that lines the thoracic wall and covers the mediastinal surface.
    - Outer most layer of thoracic cavity (contains fat) becomes more fibrous above apices of lungs.
    - **Suprarenal membrane (Sibson's fascia)—**separates the internal thoracic artery from the pleura.
- **Length: 15-27**
- **Expansion:**
    - **Above:**
        - Forms suprarenal membrane.
    - **Below:**
        - Covers the dome of the diaphragm.
    - **Medially:**
        - Forms the loose connective tissue of mediastinum.
    - **Laterally:**
        - Forms a fibro-elastic membrane which lines the thoracic wall binding the parietal pleura to inner surface of the ribs and costal cartilage.



Thoracic Wall

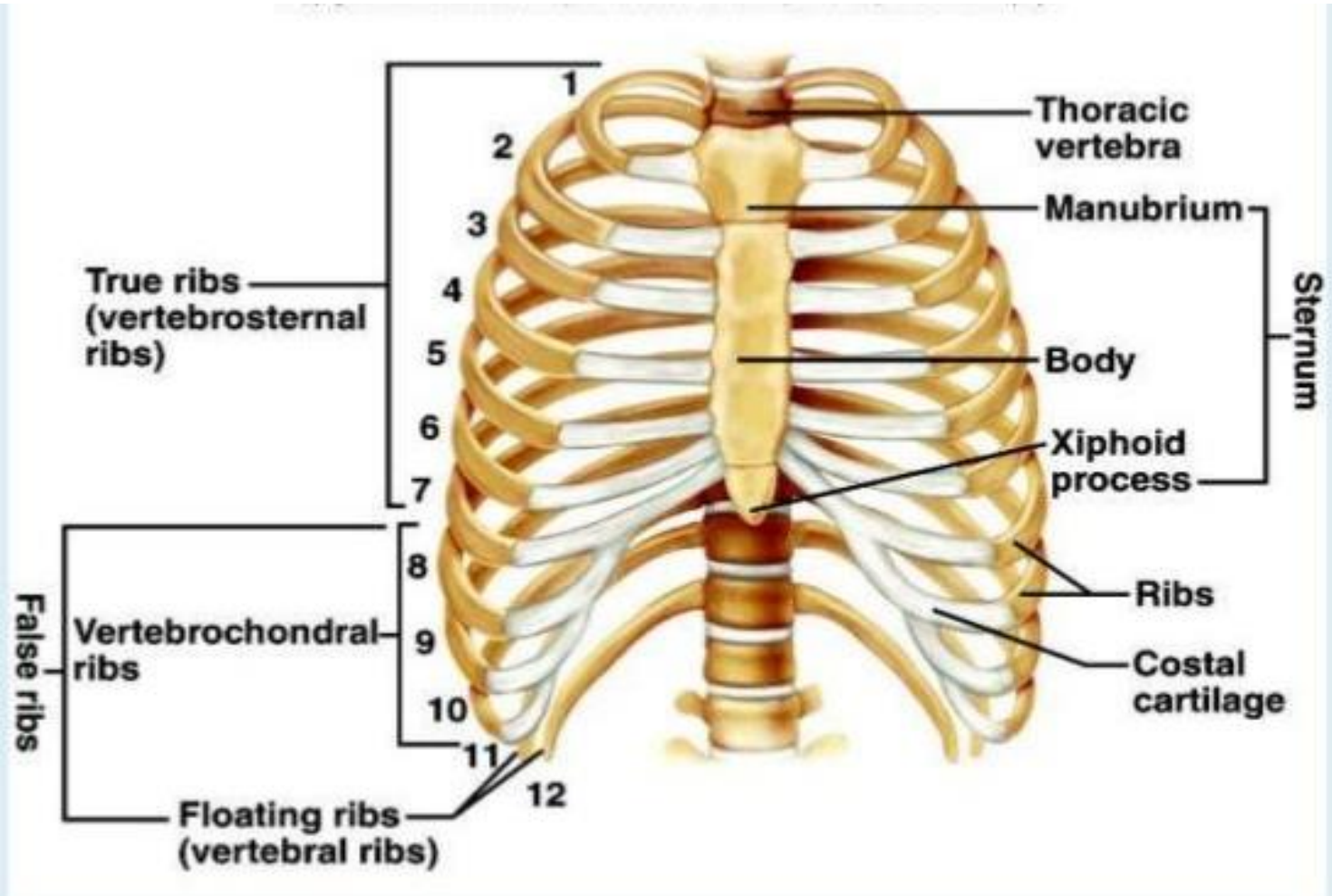


(a) Skeleton of the thoracic cage, anterior view

Thoracic Wall

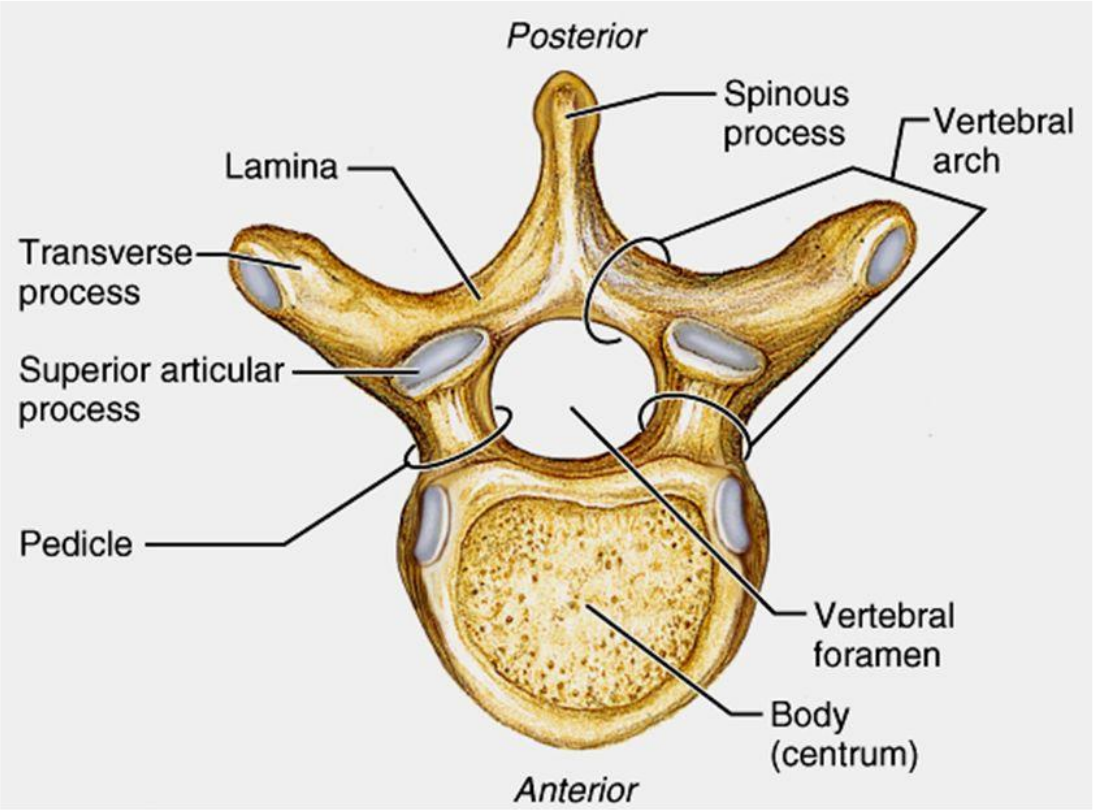
- **Definition:** it's the wall of the thorax.
- **Consists of Skeletal elements and muscles of the Thoracic Wall:**
  - **Skeletal Elements:**
    - **Posteriorly:**
      - It's made up of 12 thoracic vertebrae and their interverbal discs.
    - **Laterally:**
      - It's made up of 12 ribs on each side, and 3 layers of muscles that span the intercostal spaces.
    - **Anteriorly:**
      - It's made up of the sternum.

Bones of the Thoracic Wall



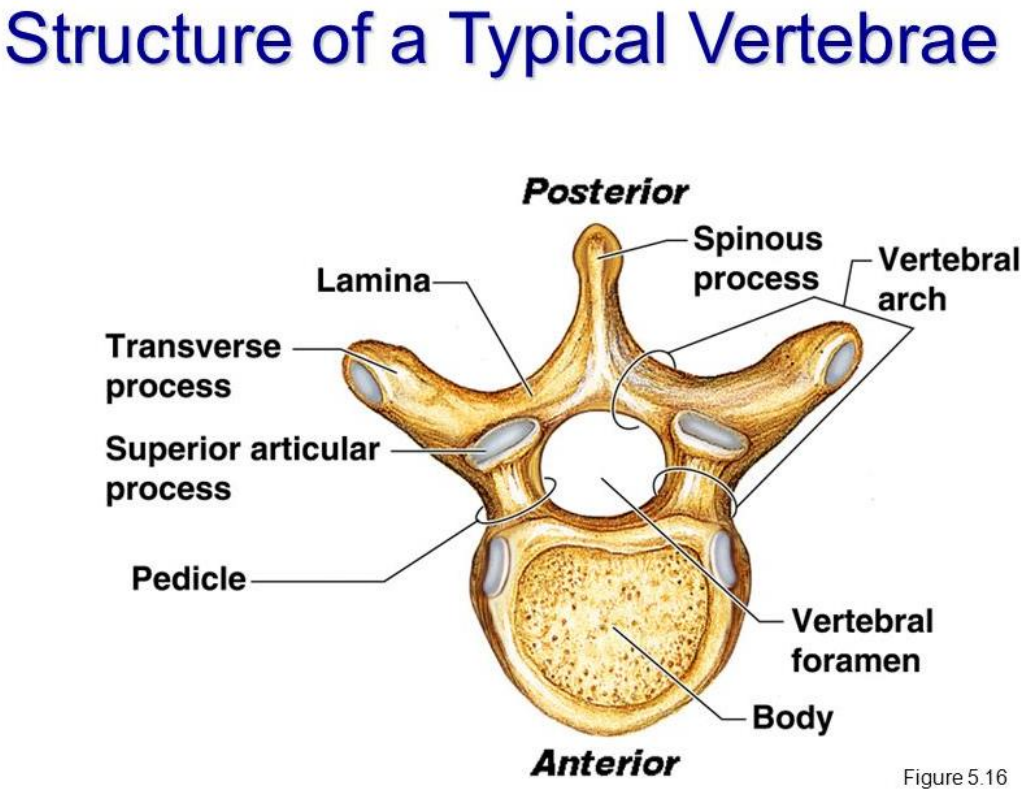
- **Thoracic Vertebrae:**
  - There are 12 thoracic vertebrae each of which is characterized by their articulation with the ribs.

General Structure of thoracic Vertebrae



- **Types of Thoracic Vertebrae:**
  - Typical Vertebrae 2nd to 8th
  - Non-typical Vertebrae 1st and 9th to 12th

- **Typical Thoracic Vertebrae:**



Typical Thoracic Vertebrae

- **Definition:** the typical thoracic vertebra has **a heart shaped** vertebral body, with roughly equal dimensions in transverse and **anteroposterior direction**. It also has a **long spinous process**.
- The vertebral foramen is generally **circular** and the **laminae are broad** and overlapped with those of the vertebra below.
- The **superior articular processes** are **flat** with their articular space facing almost directly posteriorly. While the **inferior articular** processes project from the laminae and their articular facets face anteriorly.
- The transverse processes are **club shaped** and project **posterolateral.**

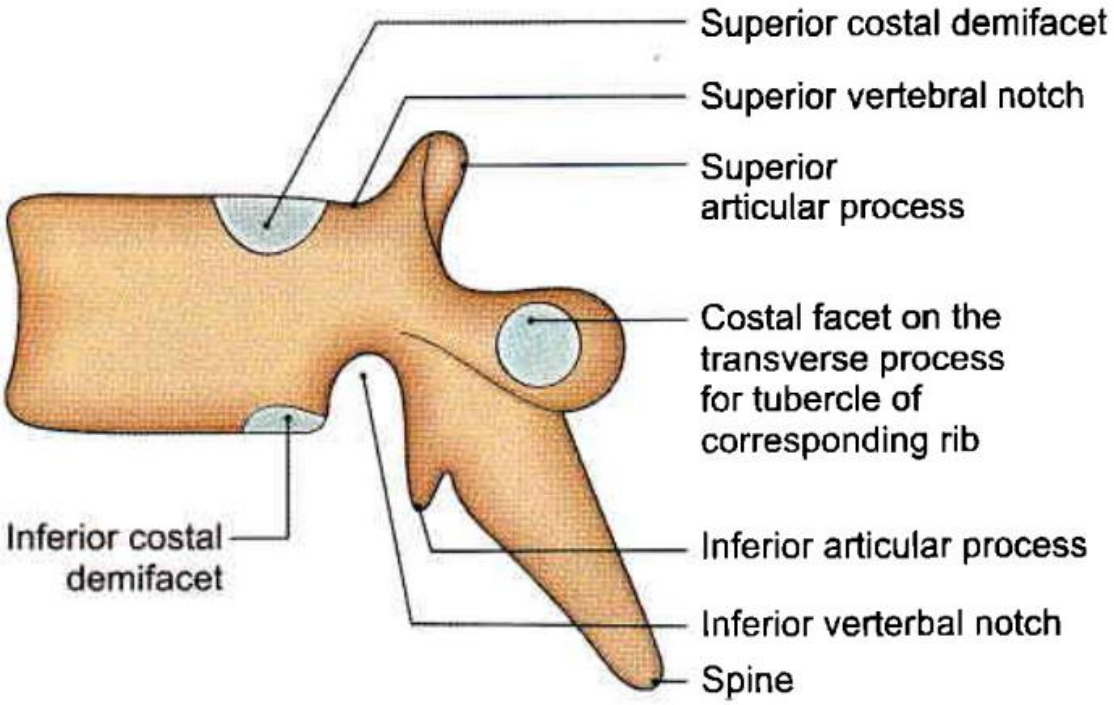


Fig. 13.18: Typical thoracic vertebra, lateral view

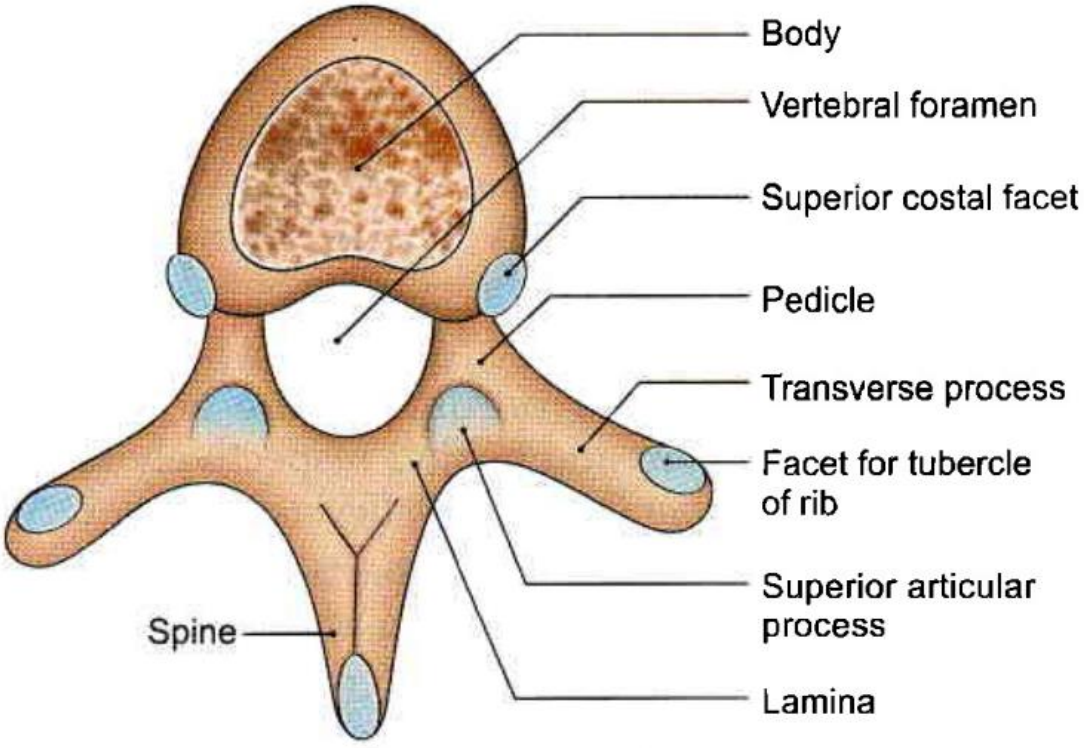


Fig. 13.17: Typical thoracic vertebra, superior aspect

Fig. 13.18: Typical thoracic vertebra, lateral view

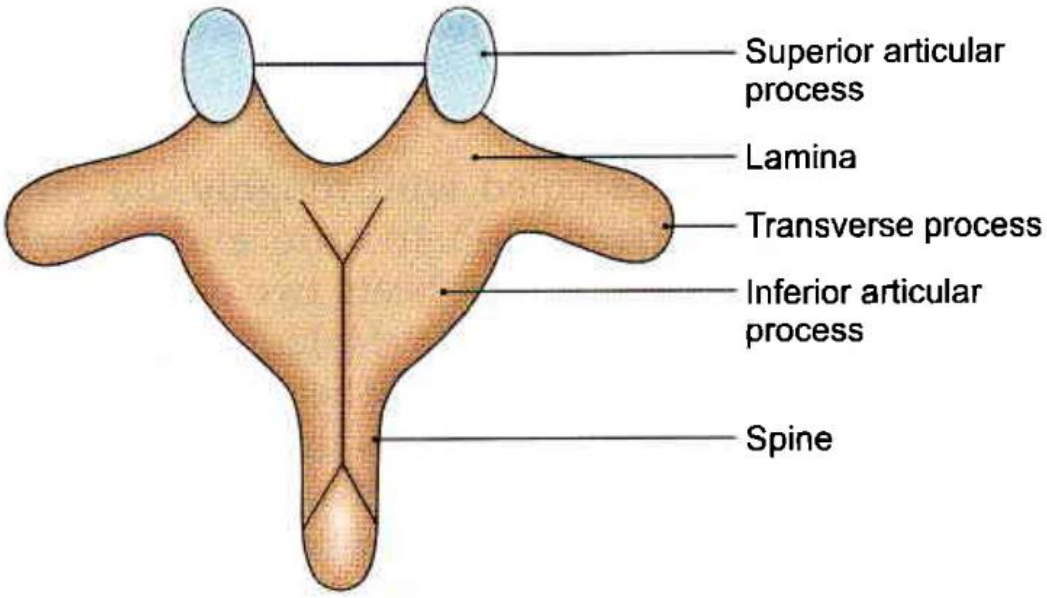


Fig. 13.19: Typical thoracic vertebra, posterior aspect

The 3 sites of articulation of Typical Thoracic Vertebra with the ribs	
Two Demi-facets "Partial Facets"	An oval facet "Transverse Costal Facets"
Are located on the superior and inferior aspects of the body for articulation with corresponding sites on the heads of adjacent ribs.	At the end of the transvers process articulates with the tubercle of its own rib

- **Note:** not all vertebrae articulate with ribs in the same fashion.

Non-Typical Vertebrae

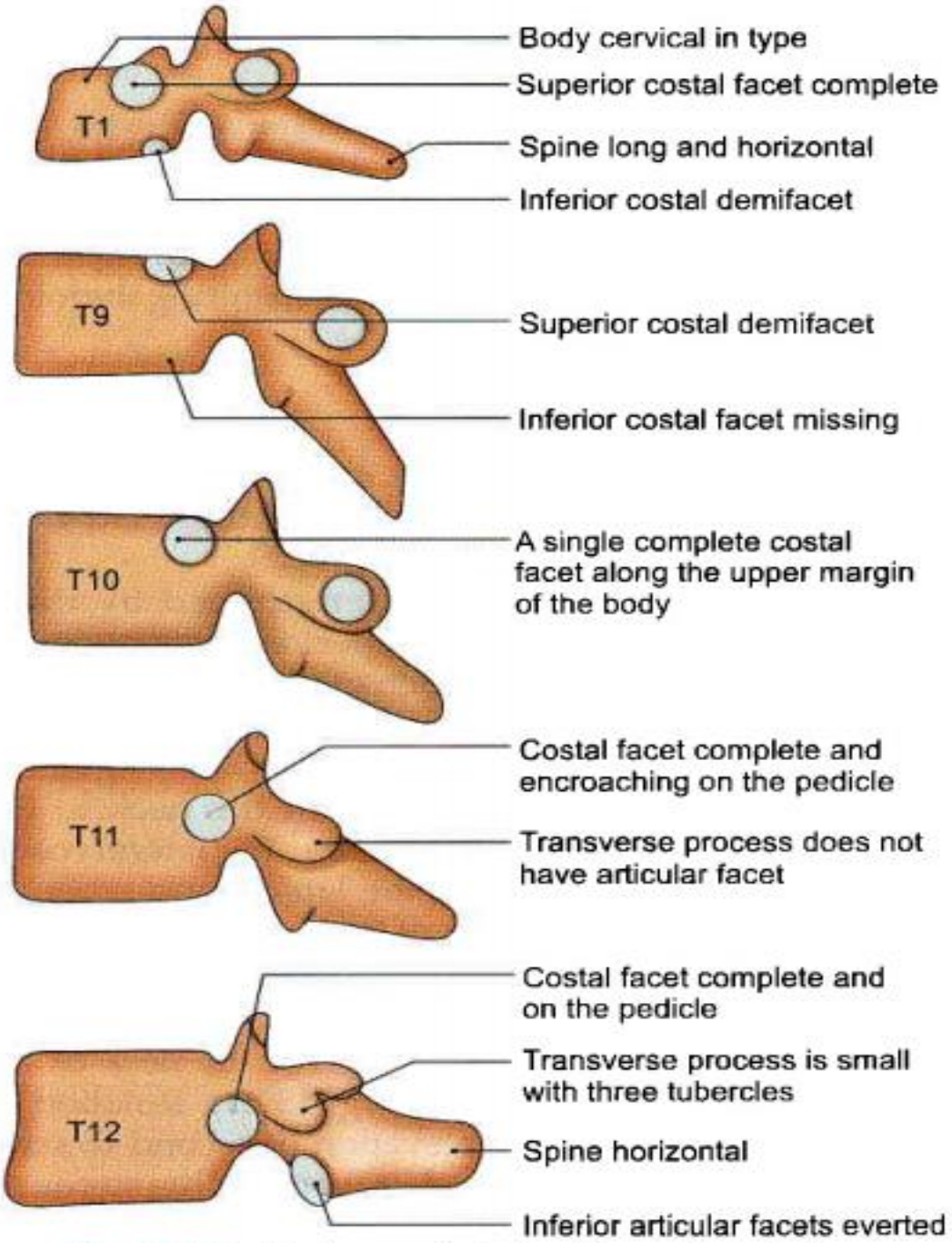
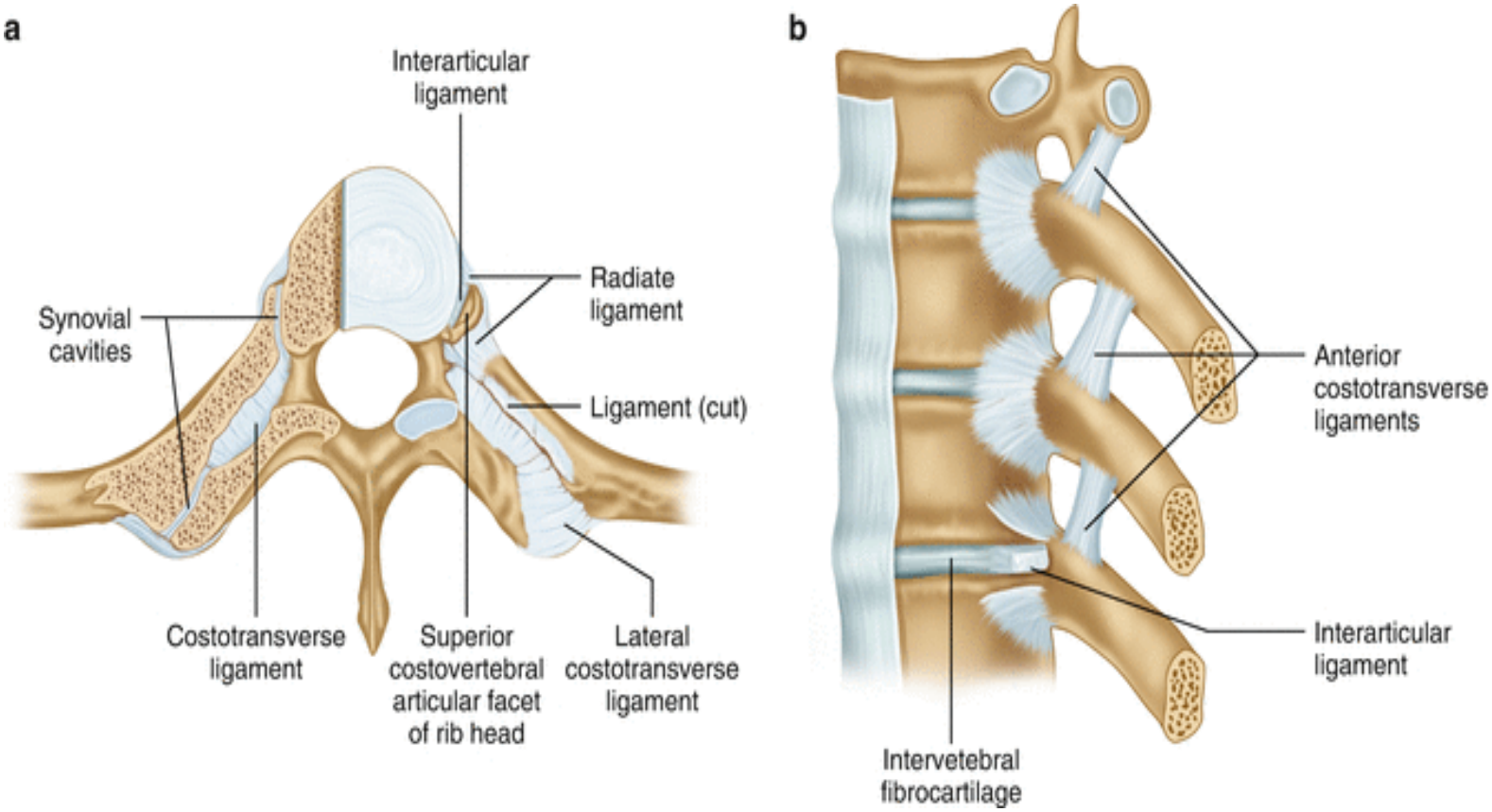

T1
Body cervical in type
Superior costal facet complete
Spine long and horizontal
Inferior costal demifacet
T9
Superior costal demifacet
Inferior costal facet missing
T10
A single complete costal facet along the upper margin of the body
T11
Costal facet complete and encroaching on the pedicle
Transverse process does not have articular facet
T12
Costal facet complete and on the pedicle
Transverse process is small with three tubercles
Spine horizontal
Inferior articular facets everted

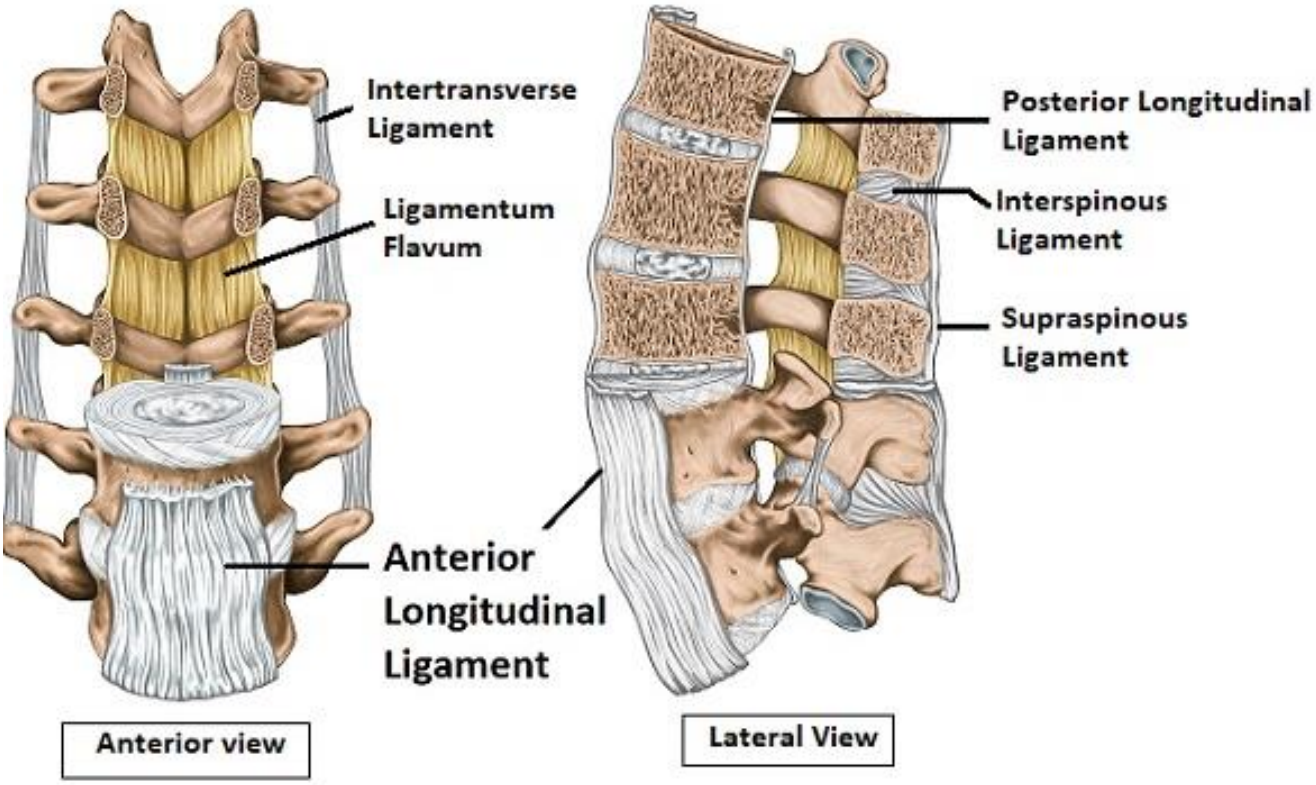
Fig. 13.21: Features of atypical thoracic vertebrae

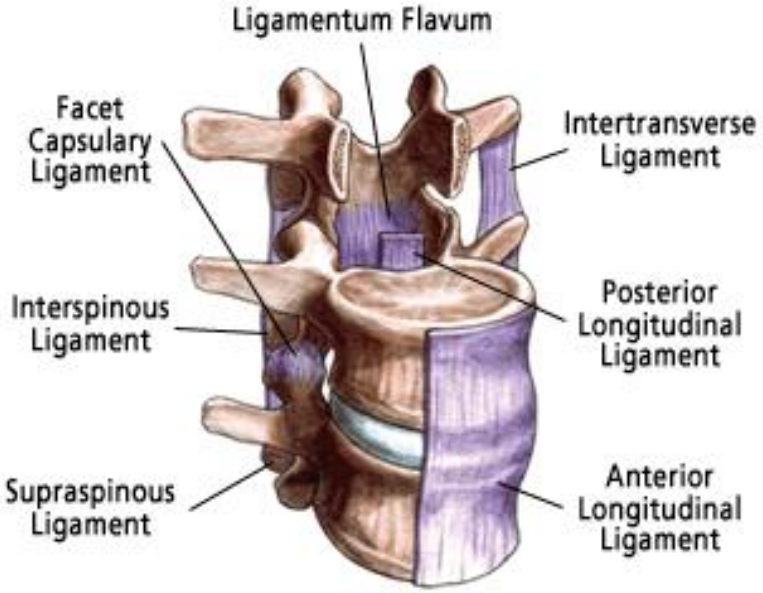
	1st Thoracic Vertebra	9th Thoracic Vertebra	10th Thoracic Vertebra	11th Thoracic Vertebra
The Body	Is small in size and kidney shaped	Is large	Is Large	Is Large
The Facet	Has 2 facets one superior for the head of the 1st rib and small inferior semilunar facet for the head of 2nd rib.	Has 2 facets one large superior semicircular for the head of 9th rib and small inferior semilunar for the head of the 10th rib.	Only one large superior semicircular facet for the head of the 10th rib.	Only one complete circular facet above for the head of 10th rib.
The Transverse Process	Has costal facet	Has costal facet	Has a small costal facet	
Another information	The vertebral foramen is triangular			

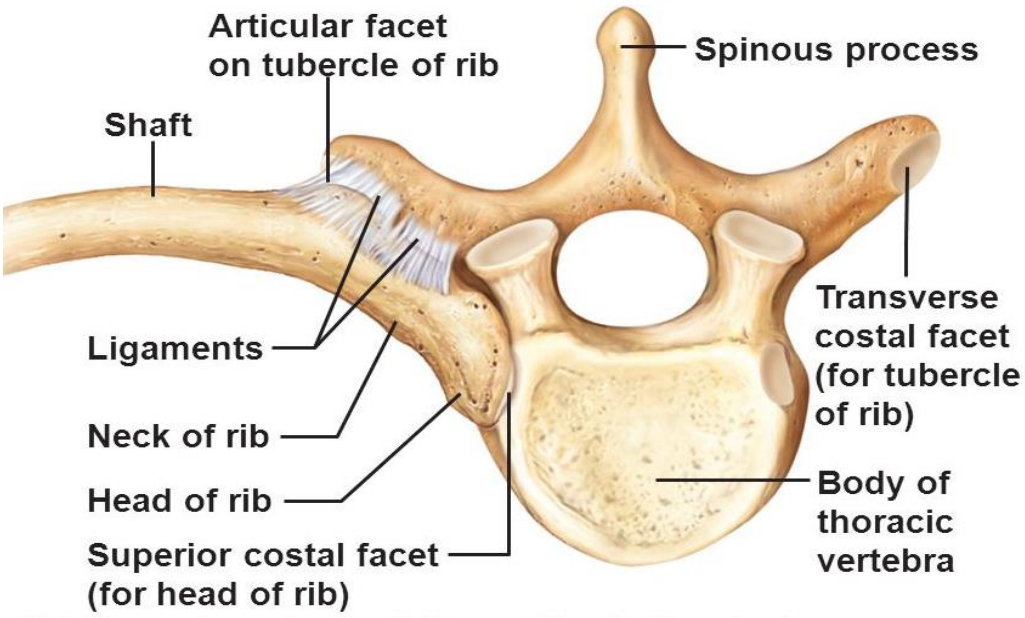
- The 12th thoracic vertebra is like the 11th thoracic vertebra but the complete circulation faced on the body encroaches on the middle of the pedicle and the inferior articular facet is directed laterally instead of forwards.

- **Vertebrae are connected together by:**
  - **Vertebral bodies:**
    - Intervertebral discs—secondary cartilaginous joint
    - Anterior longitudinal ligament
    - Posterior longitudinal ligament
  - Laminae by ligamenta Flava
  - Transverse Process by intertransverse ligaments
  - **Spines by:**
    - Interspinous ligaments
    - Supraspinous ligament
  - Articular process by fibrous capsule of intervertebral joint

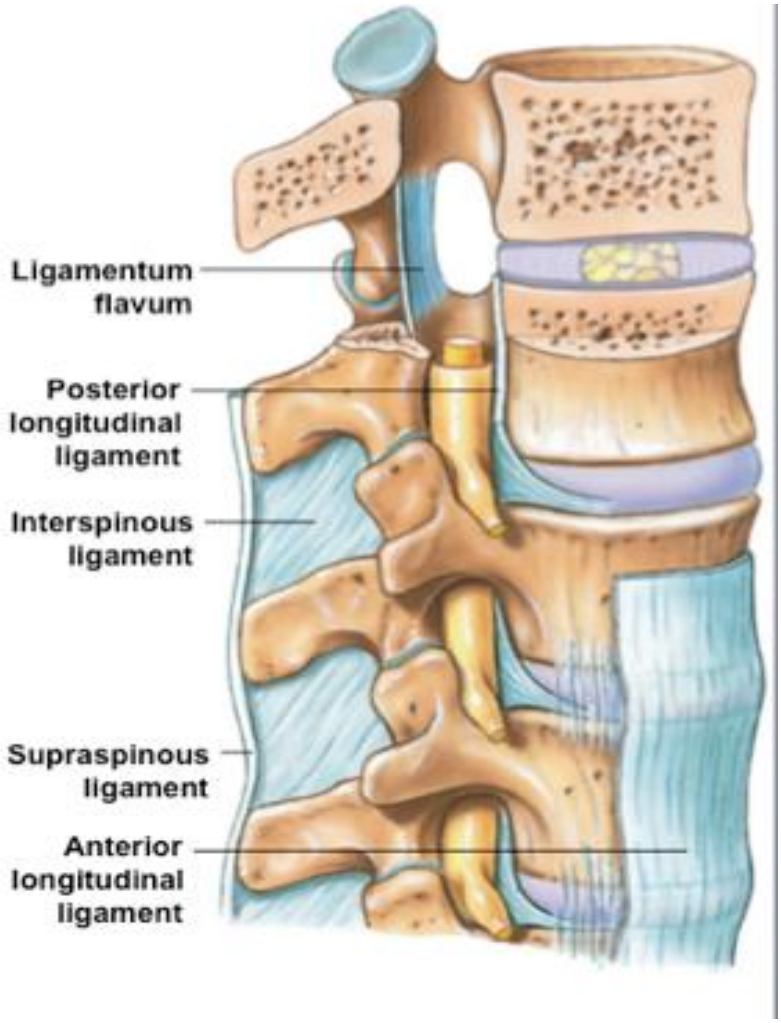



Intertransverse Ligament
Ligamentum Flavum
Anterior Longitudinal Ligament
Anterior view
Posterior Longitudinal Ligament
Interspinous Ligament
Supraspinous Ligament
Lateral View


Ligamentum Flavum
Facet Capsulary Ligament
Intertransverse Ligament
Interspinous Ligament
Posterior Longitudinal Ligament
Supraspinous Ligament
Anterior Longitudinal Ligament

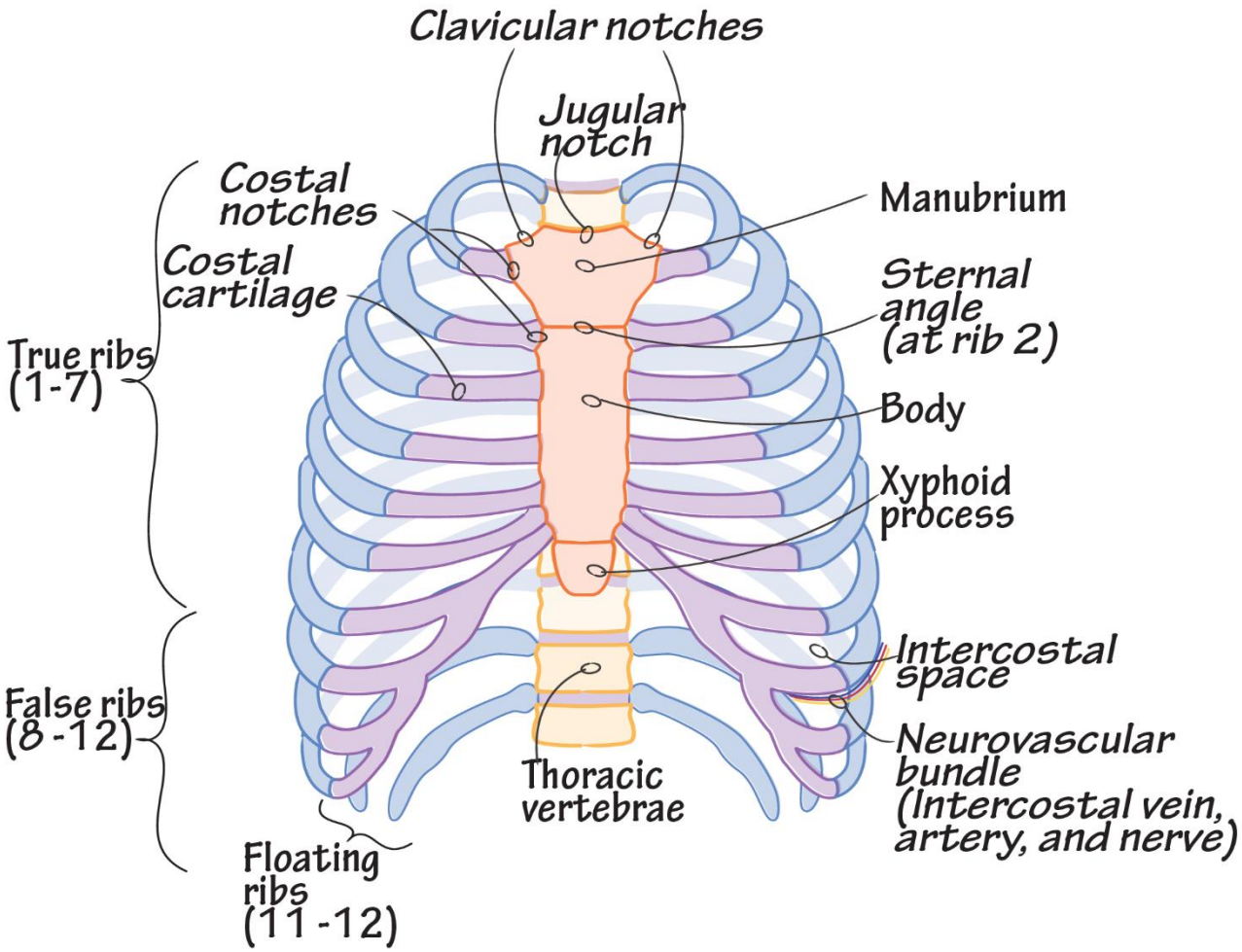


(b) Superior view of the articulation between a rib and a thoracic vertebra

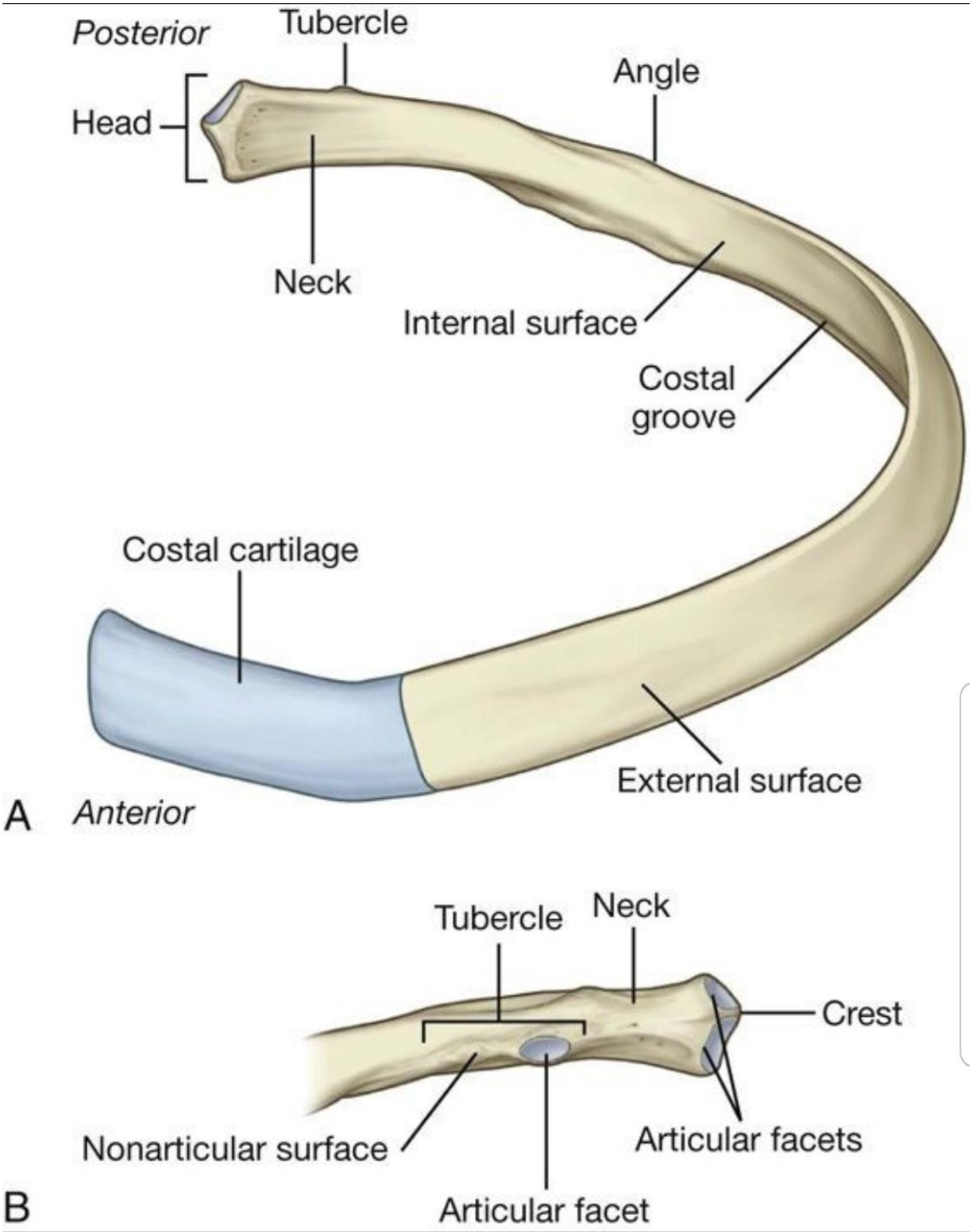


Ribs

- **Definition:** there are 12 pairs of ribs, each terminating/ending anteriorly in costal cartilage.
- **Classification of Ribs**
  - According to relation of the Sternum
    - **True Ribs:**
      - Upper 7 ribs articulate directly with the Sternum.
    - **False Ribs:**
      - 8th, 9th, and 10th ribs whose costal cartilage articulate anteriorly with the costal cartilage of ribs above.
    - **Floating Ribs:**
      - 11th and 12th ribs have no anterior connections with other ribs or with the Sternum.



Typical Ribs

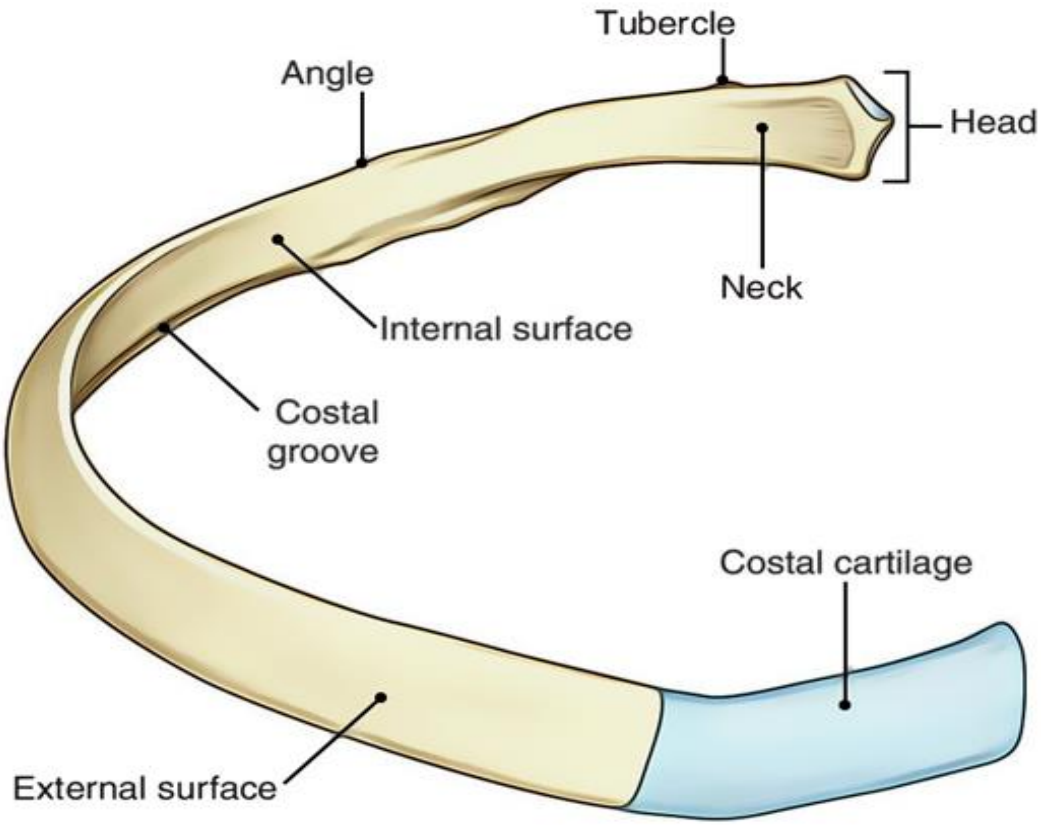


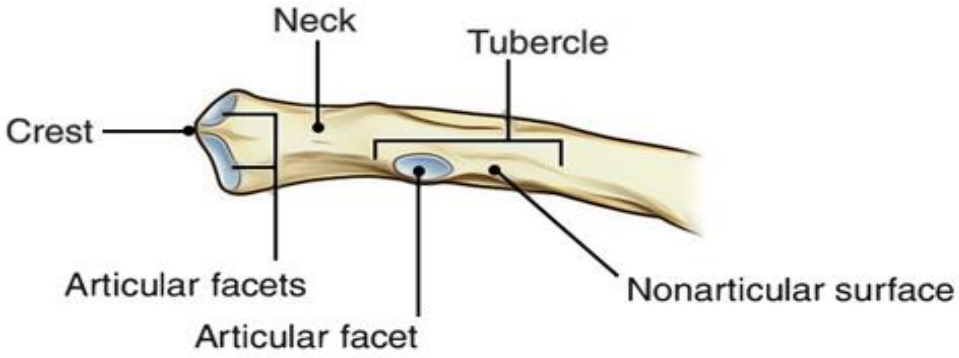
- **Each typical rib has 3 parts:**
  - **Anterior end**—its cup shaped and is continuous with its costal cartilage
  - **Shaft**
  - **Posterior end**—articulates with the vertebral column and is characterized by a:
    - Head
    - Neck
    - Tubercle
      - **Head**—has two articular surfaces separated by a crest.
        - The smaller superior surface articulates with the inferior costal facet on the body of vertebra above.
        - The large inferior facet articulates with the superior costal facet of its own vertebra.
      - **Neck**—a short flat region of the bone that separates the head from the tubercle.
      - **Tubercle**—projects posteriorly from the junction of the neck with the shaft and consists of two regions, an articular part and a non-articular part.
        - Articular part is medial and has an oval facet for articulation with a corresponding facet on the transverse process of associated vertebra.
        - Non-articular part is roughened by the attachment of ligaments.
  - **The Shaft**—is divided by angle into:
    - Posterior 1/4th which is cylindrical
    - Anterior 3/4th which is flattened has:
      - **2 Borders**
        - Upper rounded border
        - Lower sharp border
      - **2 surfaces**
        - Outer convex surface
        - Inner concave surface showing the costal groove.
          - The costal groove is the inferior margin of the internal surface.

Non-Typical Ribs

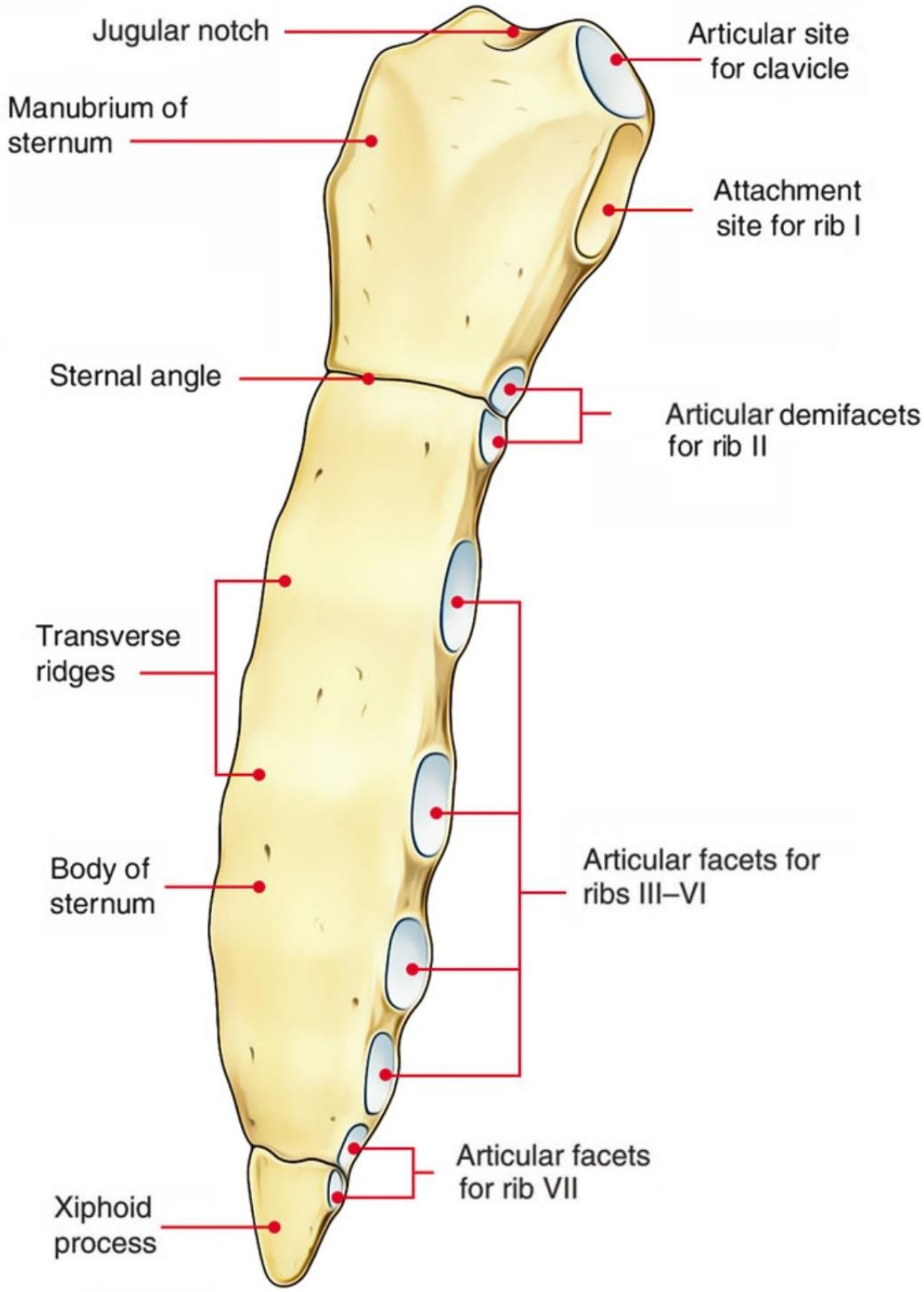
- **Frist rib**—its the highest, flattest, strongest, most curved and most fixed rib.
  - **Shaft**:
    - **Has 2 surfaces:**
      - **Lower surface—**smooth, no costal groove.
      - **Upper surface**—it's rough and has scilene tubercle, groove for subclavian vein, and groove for subclavian artery.
    - **Has 2 borders:**
      - **Inner**—concave and shows the scalene tubercle
      - **Outer**—convex and shows the rough impression "serrate tubercle"
  - **Anterior End**—is thick, flattened, and gives attachment to the 1st costal cartilage.
  - **Posterior End has**:
    - **Head**—small with one facet which articulates with a circular facet on the body of 1st thoracic vertebra.
    - **Neck**—is rounded and slopes obliquely downwards
    - **Tubercle**—is prominent and coincides with the angle.
  - **Muscles Attached**
    - Scalenus Medius Muscle
    - Serratus Anterior Muscle
    - Scalenus Anterior Muscle
    - Subclavius Muscle
- **Second Rib**—it's length is twice as long as the first rib.
  - It's head is like that of typical rib.
  - **Has 2 surfaces**:
    - **Outer**—carries a broad tubercle at the middle.
    - **Inner**—smooth and has poorly developed costal groove.
  - **Muscles Attached:**
    - Serratus Anterior Muscle
    - Scalenus Posterior Muscle
    - Serratus Posterior Superior Muscle
- **Tenth Rib**—it's a transitional rib so it may look like the 9th or 11th rib.
  - The head may have 2 articular facets.
  - Tubercle is small and may or may not have an articular facet.

- **Eleventh and twelfth Ribs**—has a large head with a single articular facet.
    - Does not have a neck, nor tubercle or angle.
    - The anterior end is pointed and tipped with cartilage.
    - The inner surface is directly upwards and medially.
    - The 12th rib differs from the 11th in being shorter and having no costal groove.





The Sternum


Jugular notch
Articular site for clavicle
Manubrium of sternum
Attachment site for rib I
Sternal angle
Articular demifacets for rib II
Transverse ridges
Body of sternum
Articular facets for ribs III–VI
Articular facets for rib VII
Xiphoid process

- **Definition:** the word sternum is derived from the Romanian word meaning "sword".
- **The adult sternum consists of 3 major elements:**
    - **Manubrium:**
        - **Length:** 2 inches long
        - **Location:** opposite 2 vertebral 3rd and 4th thoracic vertebrae.
        - **Characteristics:**
            - Has 4 notches:
                - Jugular notch in it's upper border.
                - Superolateral angle presents a clavicular notch for articulation with the sternal end of the clavicle.
                - It's lateral border has a notch for 1st costal cartilage.
                - Angle of louis—the lower border of manubrium joints the upper border of the body of the sternum.
        - **Muscles Attached:**
            - 2 on the anterior surface
                - Sternomastoid muscle
                - Pectoralis Major muscle
            - 2 on the posterior surface
                - Sternohyoid muscle
                - Sternothyroid muscle
    - **Body**
        - **Length:** 4 inches long, it's the longest part of the sternum.
        - **Location:** it lies opposite 4 ½ vertebrae T5, T6, T7, T8, and upper ½ of T9.
        - **Three Borders:**
            - Upper border—articulates with the lower border of the manubrium by a secondary cartilaginous joint which forms a forwards projection called the sternal angle.
            - Lower border—articulates with the upper border of the xiphoid process "xiphisternal junction".
            - Lateral border—carries notches for articulation with the lower part of the 2nd costal cartilage and the 3rd, 4th, 5th, 6th and the upper part of the 7th costal cartilage.

- **Xiphoid Process**
  - **Length:** it's the smallest part of the sternum.
  - **Shape:** it's shape is variable, it may be wide, thin, pointed, bifid, curved or perforated. On each of its upper lateral margin is a demifacet for articulation with the inferior end of the 7th cartilage.

- **Note:** the xiphoid process is the last bone to ossificate.

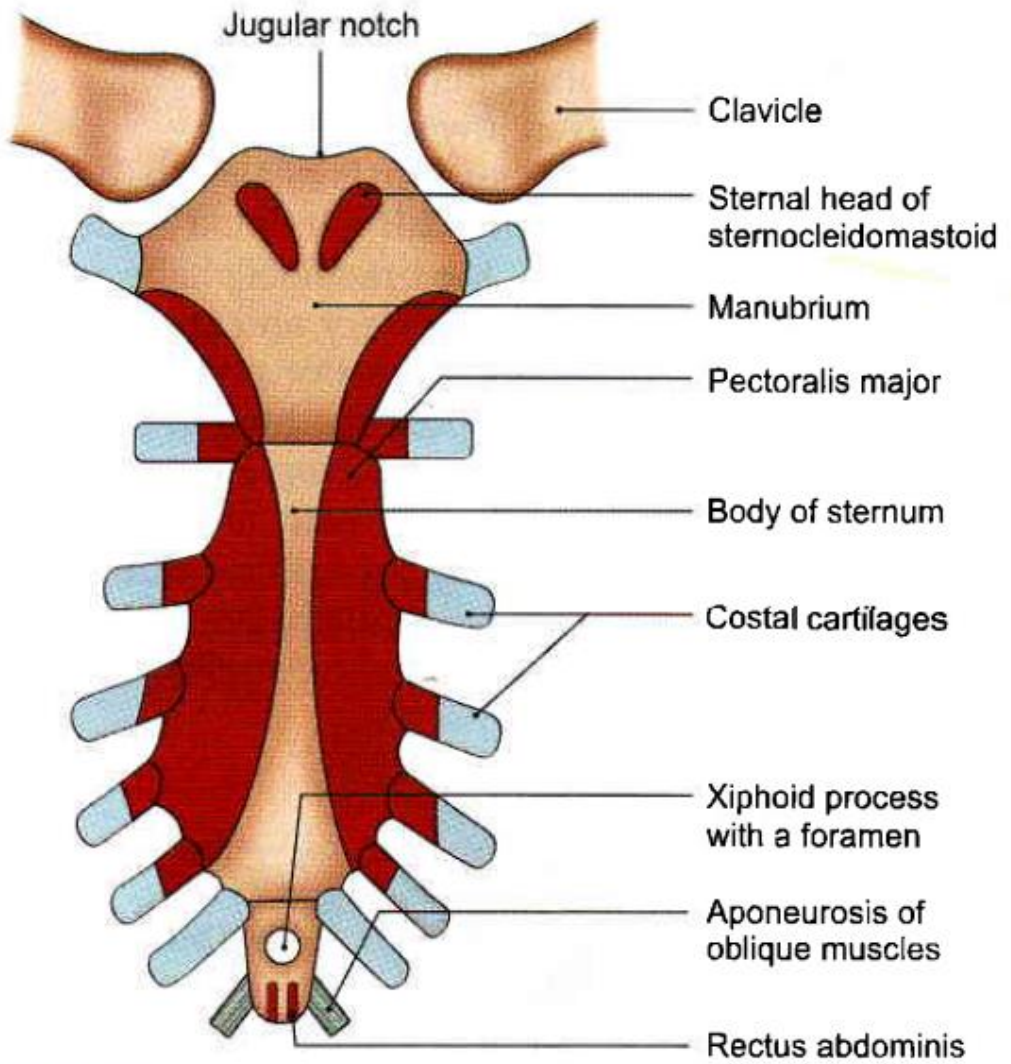


Fig. 13.9: The sternum: Anterior aspect, with muscle attachment

Joints of the Thorax

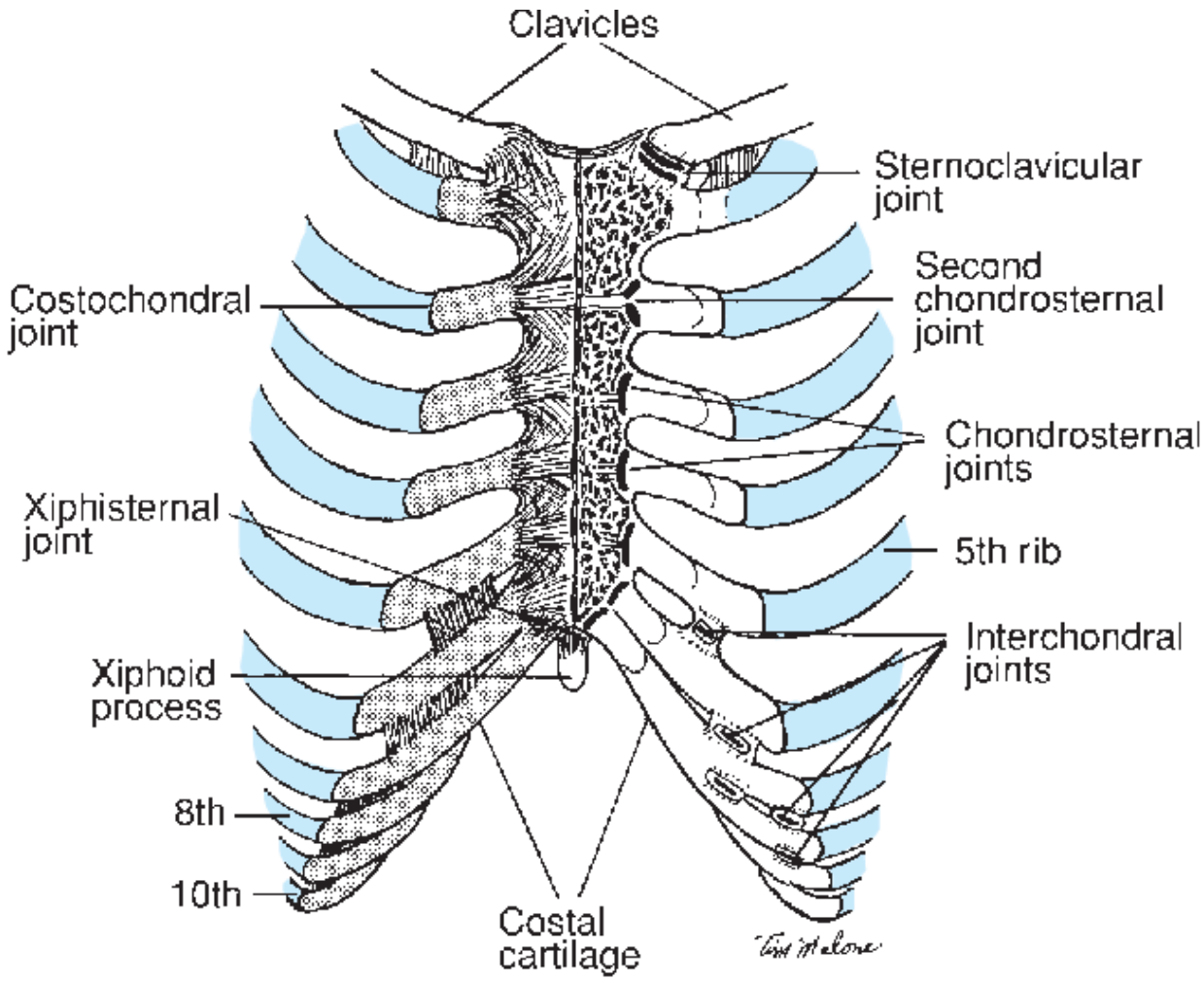


FIGURE 25.1 Anterior view of the rib cage. *(From Starr, J. Dalton, D: The thorax*

1. Sternal Joints

a. Manubrio-sternal joint

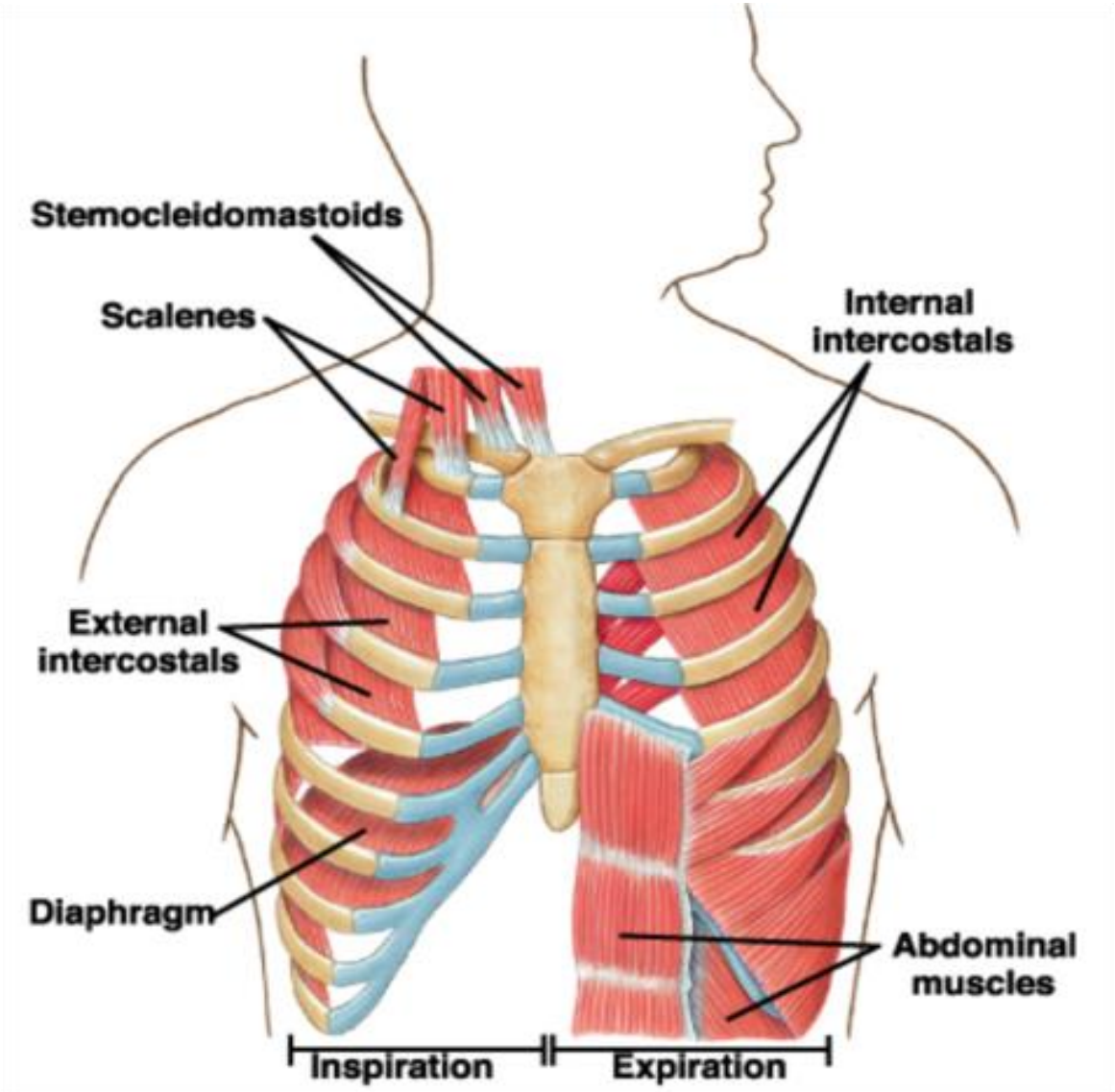
- **Definition:** it's an articulation between the manubrium and body.
- **Type:** it's secondary cartilaginous joint.

b. Xiphisternal Joint

- **Definition:** it's an articulation between the body and xiphoid process.
- **Type:** primary cartilaginous joint.

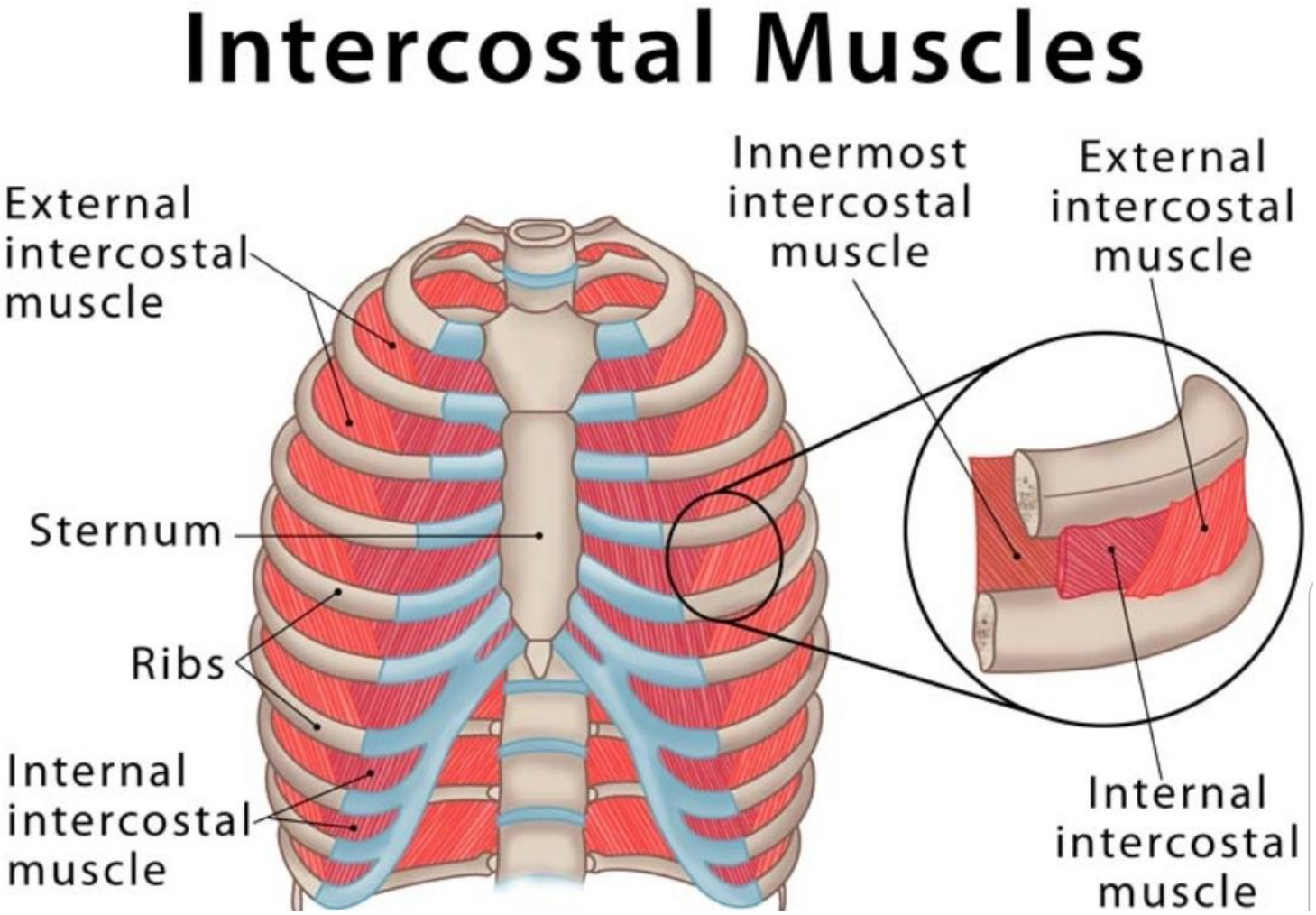
2. **Chondro-sternal Joint**
    - The 1st rib is primary cartilaginous.
    - The remaining: 2nd to 7th joints are synovial in type having capsules, and reinforced by interarticular ligaments and radit-ligaments.
3. **Costo-Chondral Joint:**
    - **Type:** primary cartilaginous.
4. **Inter-Chondral Joint**
    - **Definition:** lies between the costal cartilage 5-9th.
    - They articulate with one another by synovial joints, except for the 9th which is costal cartilage.
5. **Costal Vertebral Joints**
    - **Definition:** it's an articulation between the heads of ribs and the vertebral column.
    - **Type:** Plane Synovial Joints
    - The head of each non-typical rib (1st, 10th, 11th, and 12th) articulate with the body of the corresponding vertebra only.
    - The head of each typical rib articulates with the body of the corresponding vertebra above and the intervertebral disc between them.
6. **Costo-Transverse Joints**
    - **Definition:** the tubercle of each typical rib articulates with the transverse process of corresponding vertebra.
    - **Type:** synovial plane joint
    - The capsule of the joint is strengthened by the three ligaments:
        - Superior costo-transverse ligament
        - Lateral costo-transverse ligament
        - Inferior costo-transverse ligament

The Intercostal Space

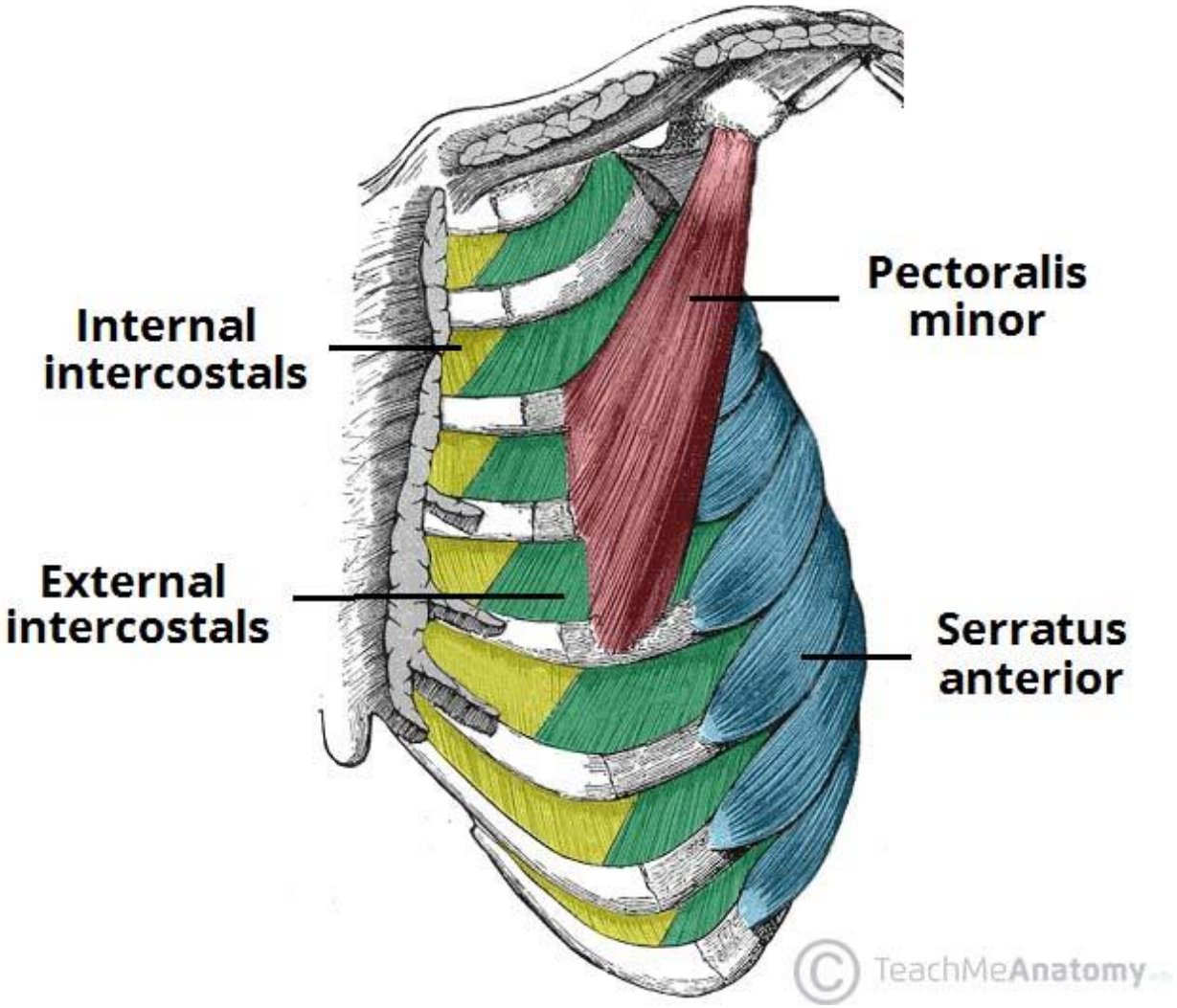


- **Definition:** is the space between 2 successive ribs.
  - They are 11 intercostal spaces between the 12 ribs on either side.

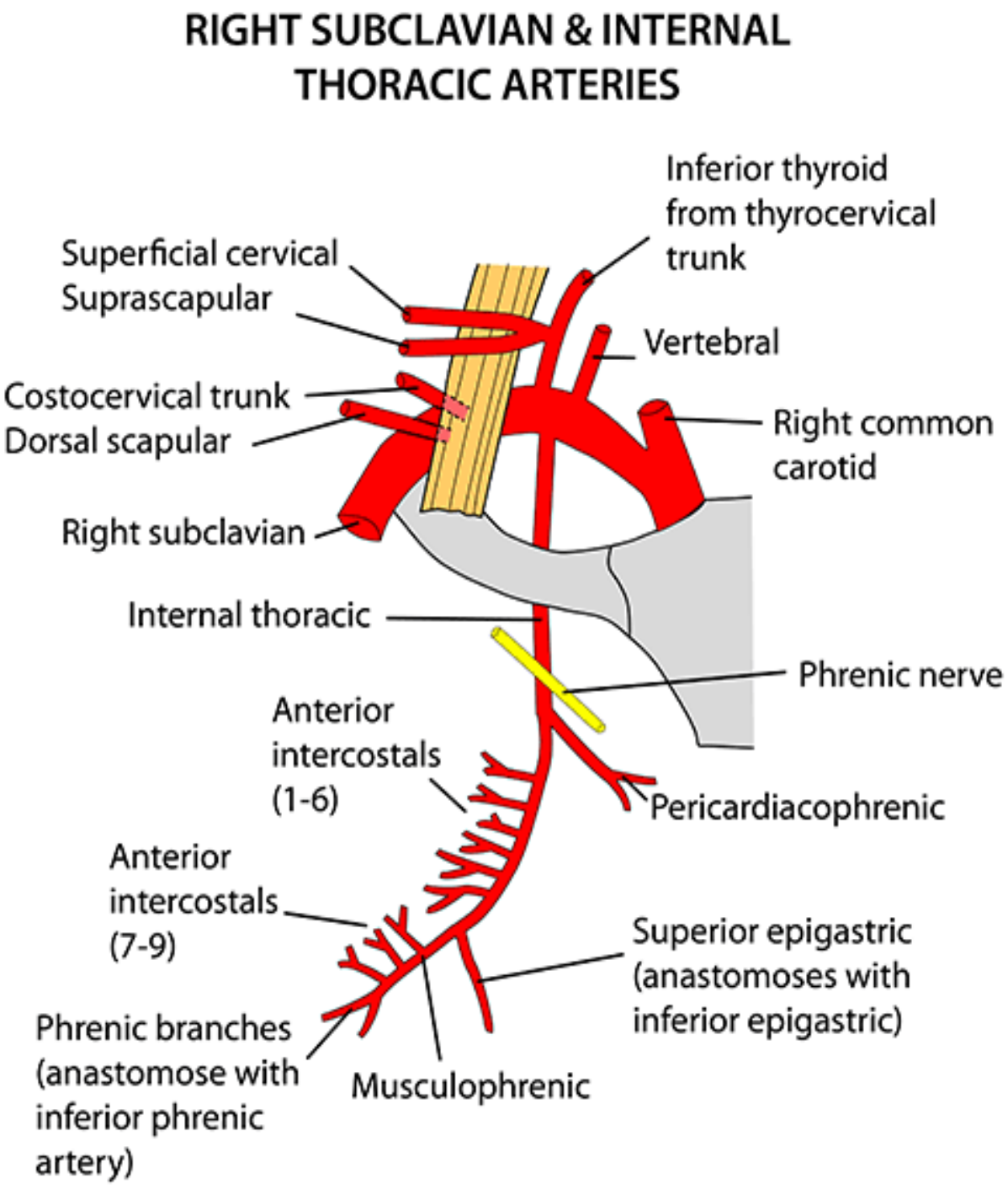
- **Each Intercostal Space Contains:**
  - **Intercostal Muscles:**
    - **Outer Layer:**
      - External intercostal muscle
    - **Middle Layer:**
      - Internal intercostal muscle
    - **Inner Layer:**
      - Transversus thoracic muscles (is made up of 3 separated muscles):
        - Sternocostalis Muscle
        - Innermost intercostal
        - Subcostalis Muscle
  - **A neurovascular bundle consisting of:**
    - Intercostal Vein
    - Intercostal Artery
    - Intercostal Nerve



Muscle	Origin	Insertion	Nerve Supply	Action
External Intercostal	From the lower border of the rib above.	Into the upper border of the rib below it.	They are all supplied by the corresponding intercostal nerves and their collateral branches.	1. The external intercostals elevate the ribs during inspiration. 2. The internal intercostals and transversus thoracis depresses the ribs and costal cartilages during expiration. 3. All muscles prevent the inwards suction of the intercostal spaces during inspiration or their outwards puffing during expiration.
Internal Intercostal	From the floor of the costal groove of the rib above.	Into the upper border of the rib below it.		
The transversus Thoracic Muscle				
a. Innermost Intercostal	Upper border of costal groove of the rib above.	Into the upper border of the rib below it.		
b. Subcostalis	Each band arises from the inner surface of the rib above.	Each band crosses one or 2 ribs to be inserted into the upper border of the 2nd or 3rd rib below it.		
c. Sternocostalis	4 or 5 slips from the posterior surface of the lower ½ of the sternum.	The slips run upwards and laterally to be inserted into the inner surfaces of the costal cartilages from the 2nd to the 6th.		

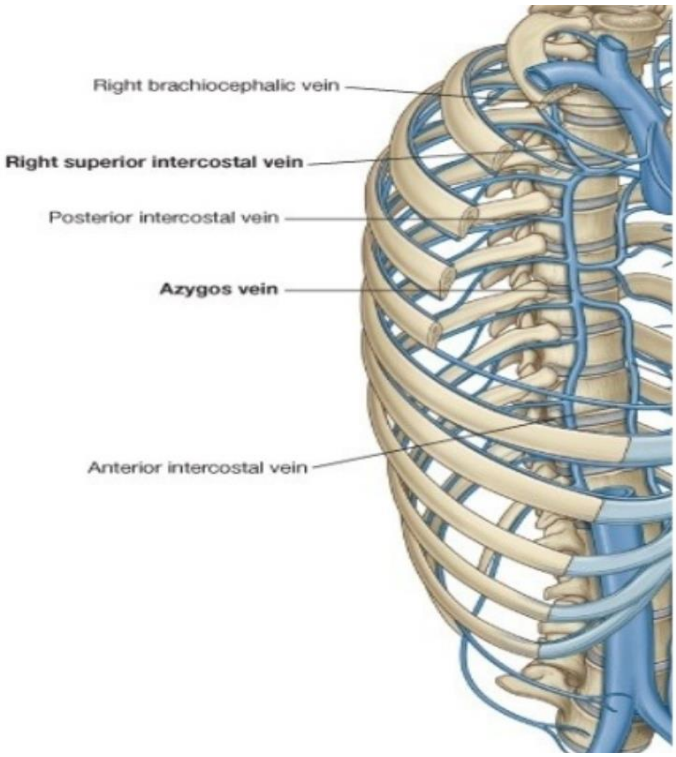

Internal intercostals
External intercostals
Pectoralis minor
Serratus anterior
© TeachMeAnatomy

Arterial Supply of the Thoracic Wall:



- **The Intercostal Arteries:**
    - **The Anterior Intercostal Arteries:**
        - There are 2 anterior intercostal arteries in each of the 11 intercostal spaces.
        - **Begins:** the arteries are branches of the internal mammary artery.
    - **The Posterior Intercostal Arteries:**
        - There is one posterior intercostal artery in each of the 11 intercostal spaces.
        - **Begins:**
            - The 1st and 2nd are branches of the superior intercostal artery which is a branch of the costocervical trunk arising from the 2nd part of the subclavian artery.
            - From 3rd to 11th are branches of the descending thoracic aorta.
- **Internal Mammary (Internal Thoracic) Artery:**
    - **Begins:** in the root of the neck from the lower aspect of the 1st part of subclavian artery.
    - **Ends:** opposite the 6th intercostal space by dividing into two terminal branches, the superior epigastric artery and musculophrenic artery.
        - **Branches:**
            - Pair of anterior intercostal arteries
            - Perforating branches
            - Pericardiaco-phrenic artery
            - Pericardial branches
            - Sternal branches
            - Mediastinal branches
            - Musculophrenic artery
            - Superior epigastric artery

Venous Drainage of the Thoracic Wall



- **The Intercostal Veins:**
  - **Anterior Intercostal Veins:**
    - The anterior intercostal veins of the 1st, 2nd, and 3rd spaces join the internal mammary vein.
    - The anterior intercostal veins of 4th, 5th, and 6th spaces join the vena comitans (accompanying vein) of internal mammary artery.
    - The anterior intercostal veins of the 7th, 8th and 9th spaces joint eh vena comitans (accompanying vein) of the musculophrenic artery.

- **Posterior Intercostal Veins:**
  - There are 11 posterior intercostal veins on each side one found in each space.

On the Right Side		
The 1st vein ends in the right innominate vein.	The 2nd, 3rd, and 4th veins unite to form right superior intercostal vein which ends int eh arch of azygos	The remaining veins: from the 5th to 11th and subcostal vein end separately in the azygos vein.

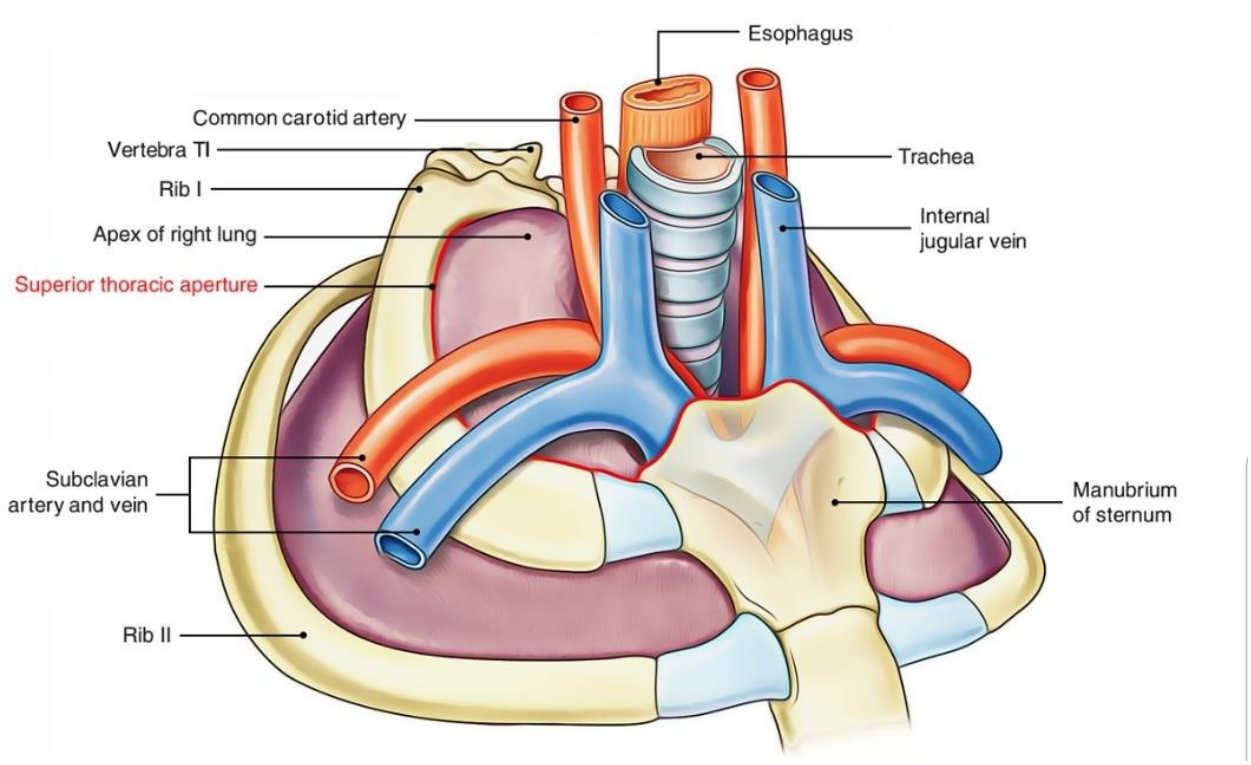
On the Left Side			
The 1st vein ends in the left innominate vein.	The 2nd vein unites with the left superior intercostal vein which opens into the left innominate vein.	The 5th to 8th veins end in the superior (accessory) hemiazygos vein which turns to the right crossing the body of T8 vertebra to open into the azygos vein.	The 9th to 11th and the subcostal vein end in the inferior hemiazygos vein which turns to the right crossing the body of T9 vertebra to open into the azygos vein.

- **Note:** all the venous blood of the thoracic wall drains finally into the superior vena cava.

Nerve Supply of Thoracic Wall

- **The Intercostal Nerves**
  - **Classification:**
    - **2 Special Nerves**:
      - **The first nerve**—ascends to join the brachial plexuses.
      - **The last subcostal nerve**—in the abdominal wall.
    - **A typical Intercostal Nerve (2-6):**
      - **Begins:** arises as the anterior primary rams of the spinal nerve.
      - **Ends:** at the cutaneous nerve
      - **Branches:**
        - Ganglionic branches
        - Collateral branch
        - Lateral cutaneous branch
        - Anterior cutaneous branch
        - Muscular branch
        - Pleural and peritoneal branches
        - Articular branches
    - **The Non-Typical Intercostal Nerve (ThoracoAbdominal nerves 7-9):**
      - They are the lower 5 intercostal nerves.
      - **Branches:** the same as those of the typical nerves. In addition, it gives branches to the abdominal muscles and supplies the kin of the anterior abdominal wall.

The Thoracic Inlet



- **Definition:** also known as superior thoracic aperture, refers to the opening at the top of the thoracic cavity.
    - It consists of the body of vertebra T1 posteriorly, the medial margin of rib 1 on each side and the manubrium anteriorly.
- **Shape and size:** it has the shape and size of a kidney
- **Boundaries**
    - **Anteriorly:**
        - The upper border of manubrium
    - **Posteriorly:**
        - The body of the 1st thoracic vertebra
    - **On each side:**
        - The 1st pair of ribs and their costal cartilage
- **Important Structures Passing through it:**
    - **Median part**—structures that pass in-between the neck and thorax
    - **On each side**—structures that are covered by:
        - Cervical Pleura
        - Suprarenal membrane

- **Viscera:**
  - Trachea
  - Esophagus
  - Appears of right and left lung
- **Arteries:**
  - Innominate artery
  - Left common carotid artery
  - Left subclavian artery
- **Nerves:**
  - Right and left vagus
  - Right and left phrenic
  - Right and left chain
  - Left recurrent laryngeal nerve
  - Right and left anterior primary rami of 1^{st} thoracic nerves
- **Veins and lymphatics:**
  - Right innominate vein
  - Left innominate vein
  - Thoracic duct

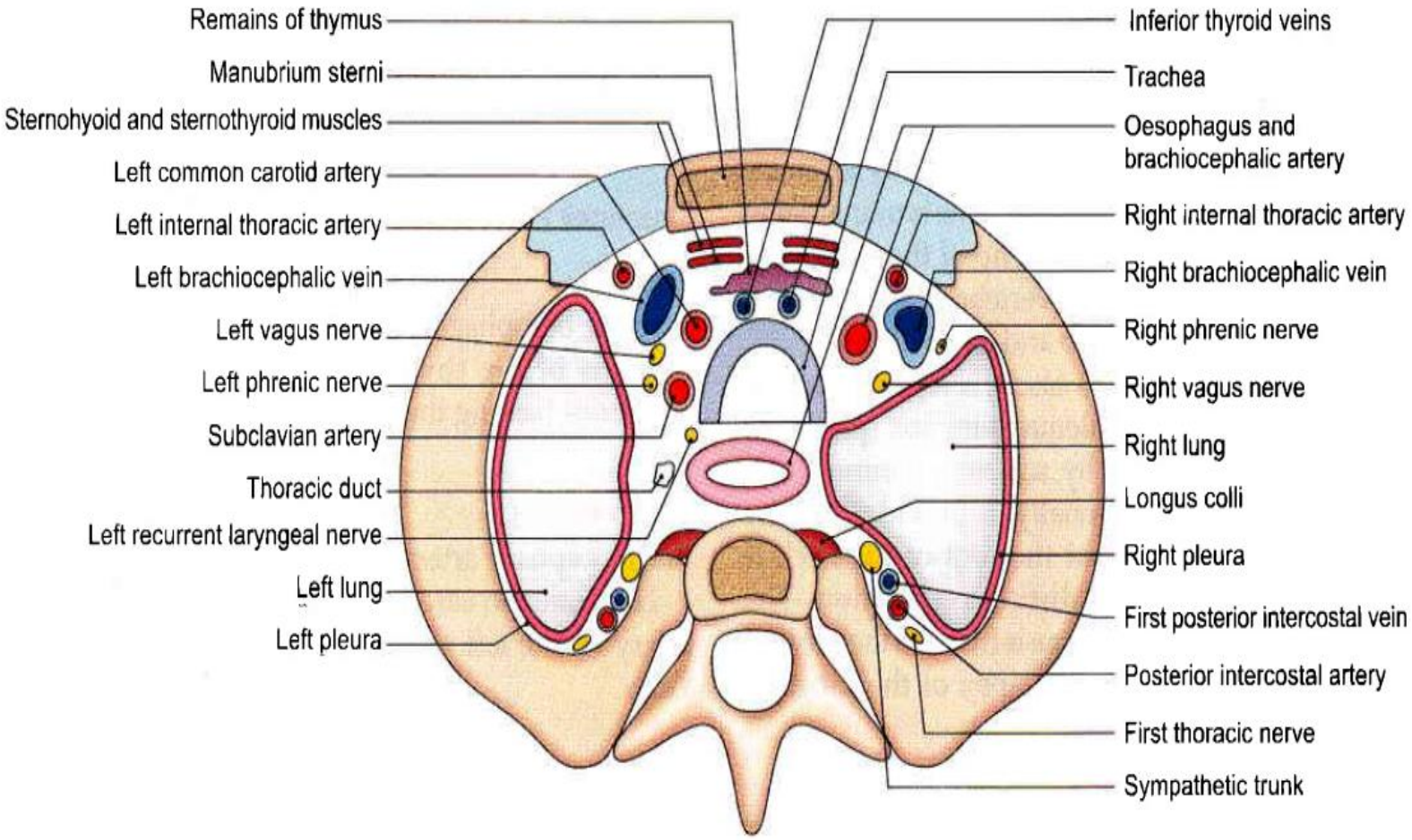
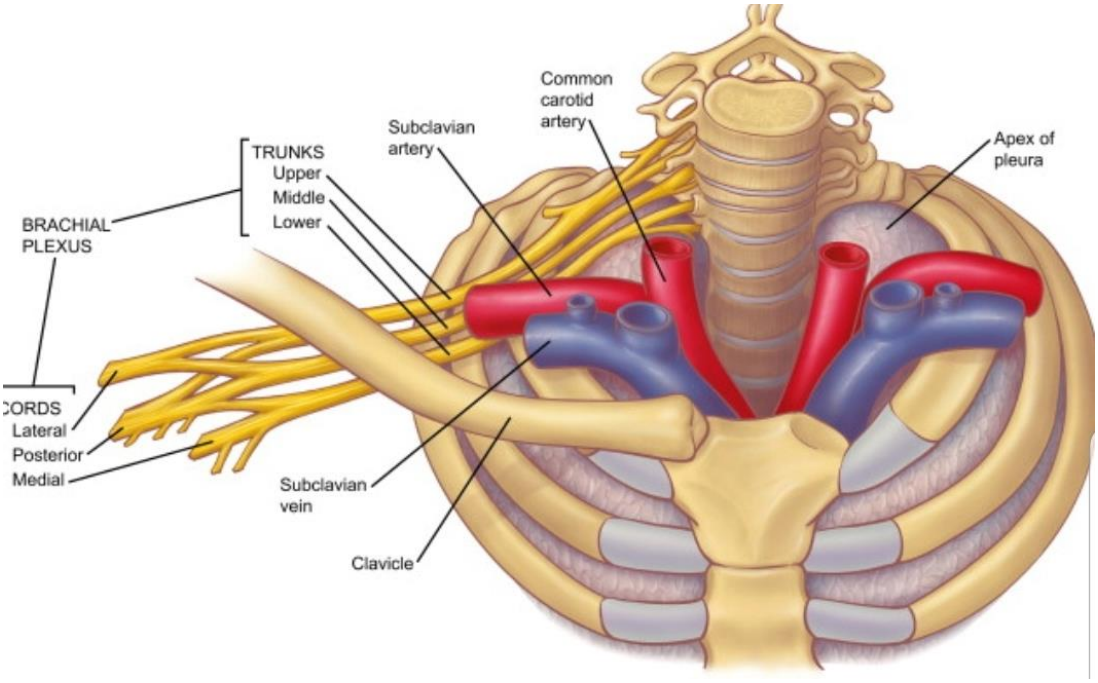


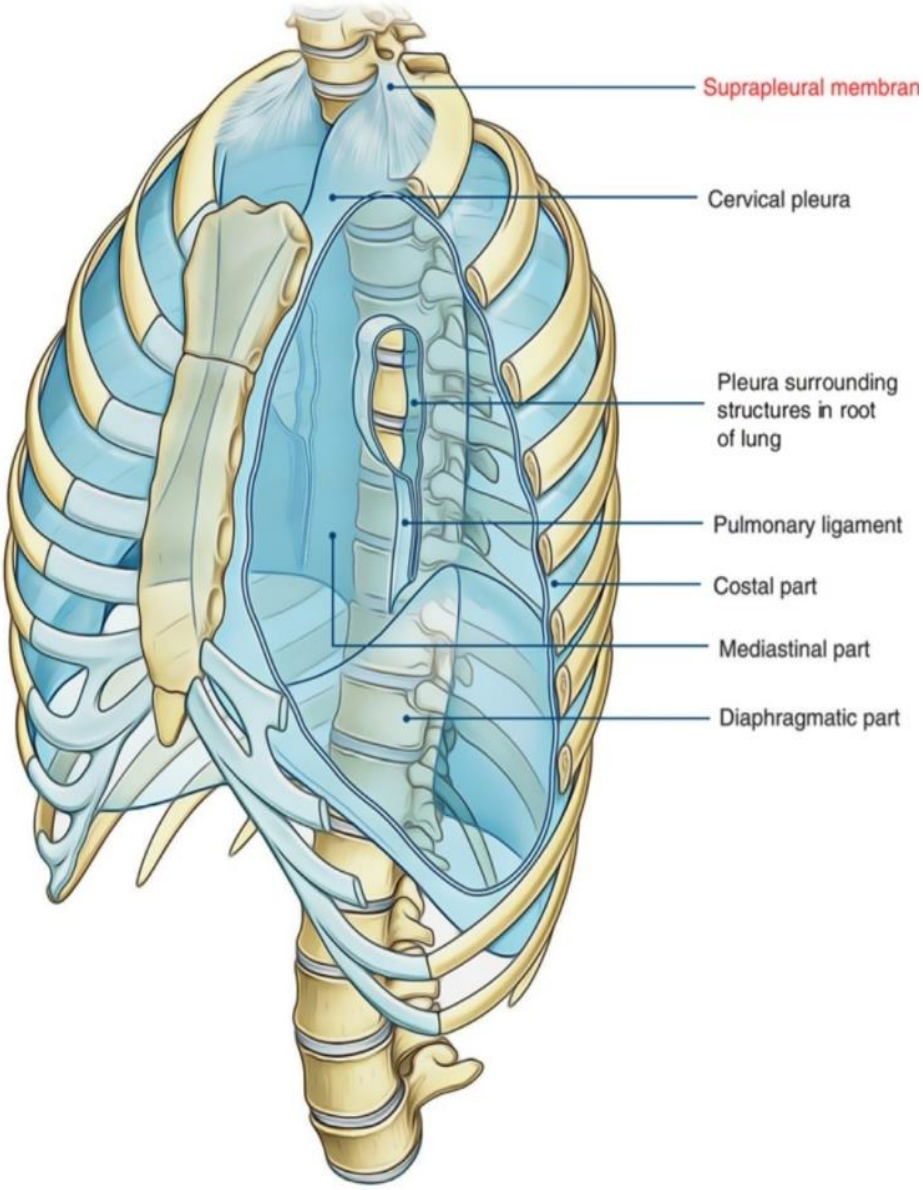
Fig. 12.12: Structures passing through the inlet of the thorax

The Thoracic Outlet



- **Definition:** also known as inferior thoracic aperture refers to the opening at the lower part of the thoracic cavity at its junction with the abdomen.
- **Boundaries**
  - **Anteriorly:**
    - The xiphoid process
  - **Posteriorly:**
    - T12 vertebra and the 11^{th}, 8^{th}, 9^{th}, 10^{th} costal cartilages fused together.
- The thoracic outlet is closed by the diaphragm which is pierced by many structures on their way to or from the abdomen including the inferior vena cava, esophagus abdominal aorta and thoracic duct.
- **Note:** the thoracic outlet is much larger than the thoracic inlet.

The Supra-Pleural Membrane

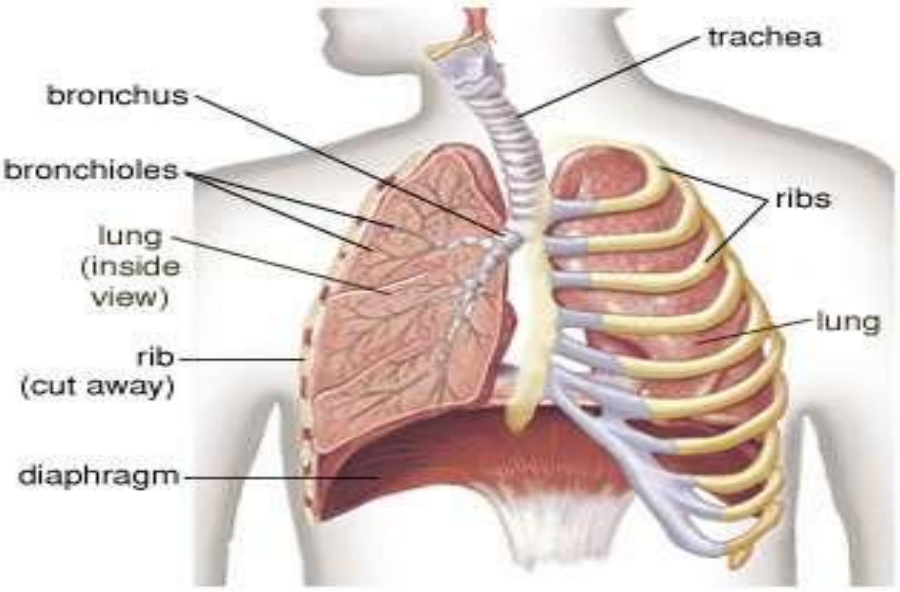


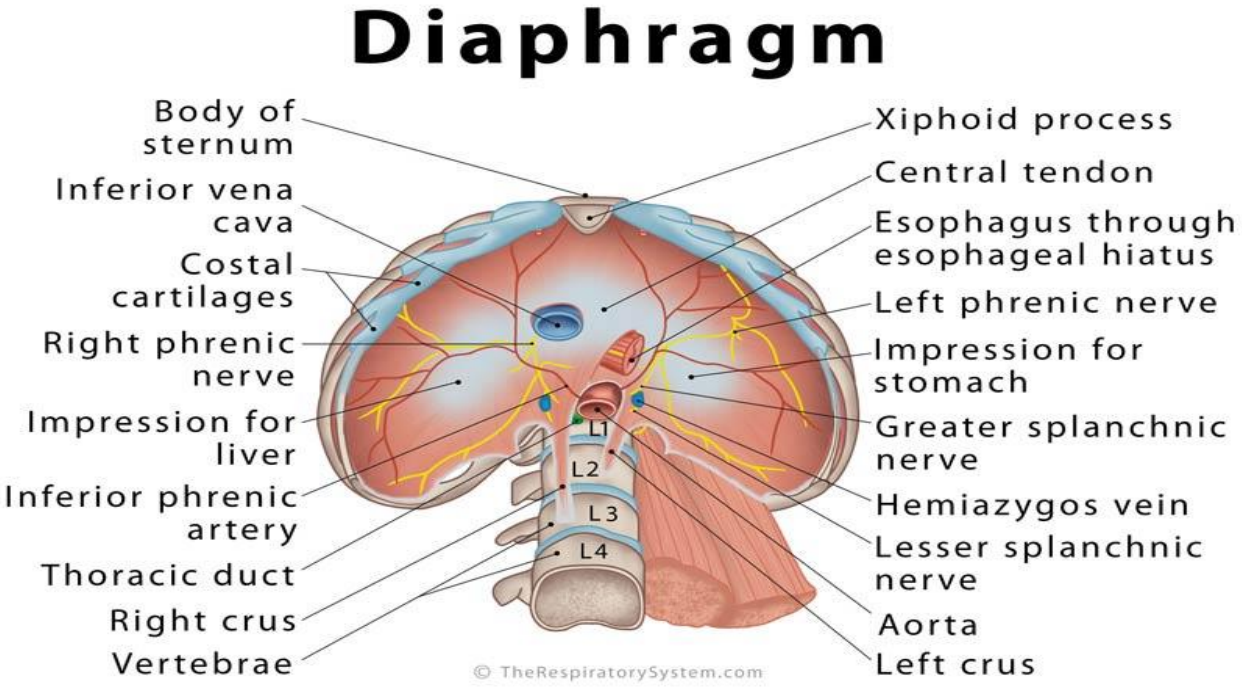
- **Definition:** it's the upper thickened part of the endothoracic fascia forming a tough membrane stretching across the inlet of thorax on either side.
- **Shape:** triangular, it has an apex and base.
- **Attachment:**
  - **Apex**—to the transverse process of the 9th vertebra.
  - **Base**—to the medial border of 1st rib and 1st costal cartilage.
  - **Medially**—it blends with the fascia investing the structures passing in between the neck and thorax.

- **Function:**
  - It prevents the inwards section of the structures at the root of the neck with every inspiratory movement.
  - It prevents the upward puffing of apex of the lung during the expulsive expiratory efforts.

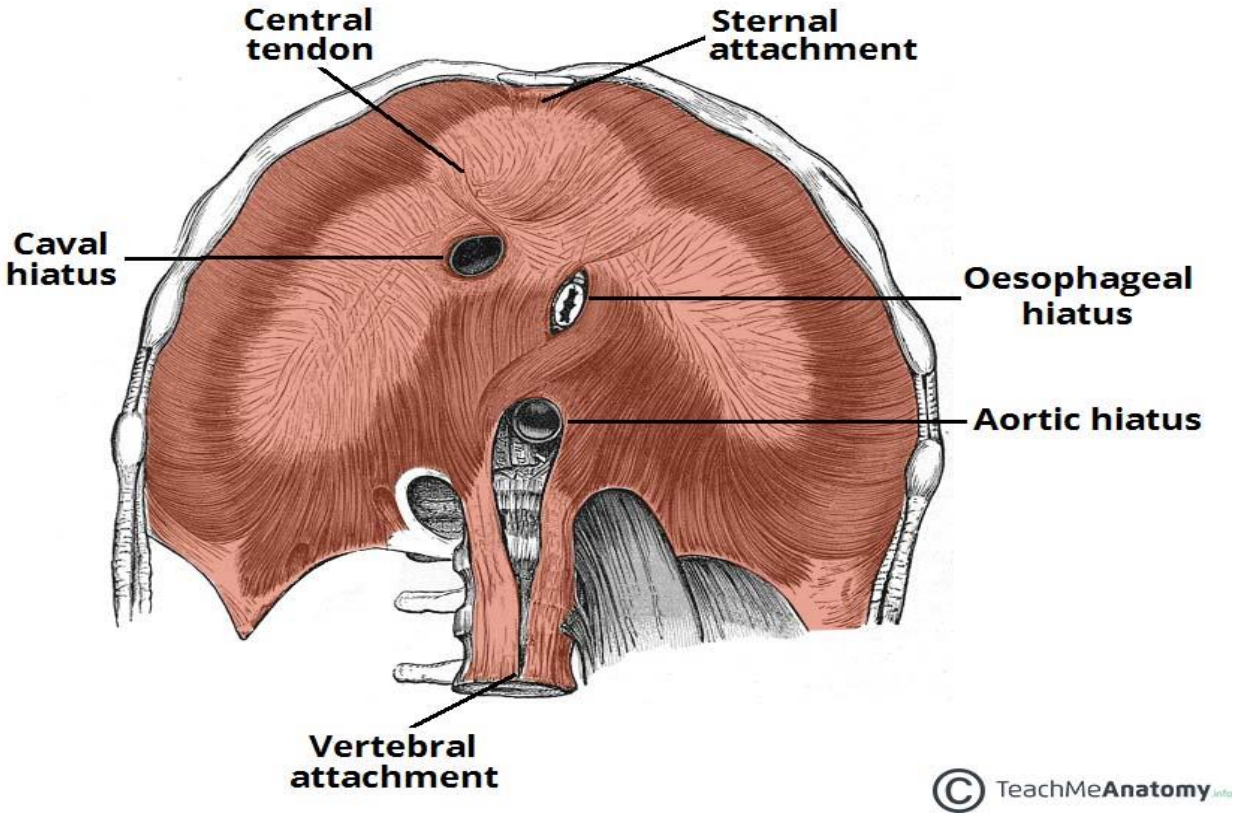
Diaphragm

- **Definition:** it is dome shaped muscle forming the partition between the thoracic and abdominal cavities.
    - It is the chief muscle of the respiration.
- **Shape:** large dome
    - Its upper surface is convex toward the thoracic
    - Its lower surface is concave toward the abdominal
- **Origin:** it is divided into 3 parts:
    - **Sternal Part:**
        - Origin by 2 lips from the back of xiphoid process.
    - **Costal Part:**
        - Origin by slips from inner surface of lower 6 ribs and their costal cartilages.
    - **Vertebral Part:**
        - Origin from the medial and lateral lumbocostal arches and from lumbar vertebrae by right and lift crura.
- **Insertion:**
    - The fibers of the sternal, costal and vertebral origin converge to be inserted into a crescentic shaped central tendon.





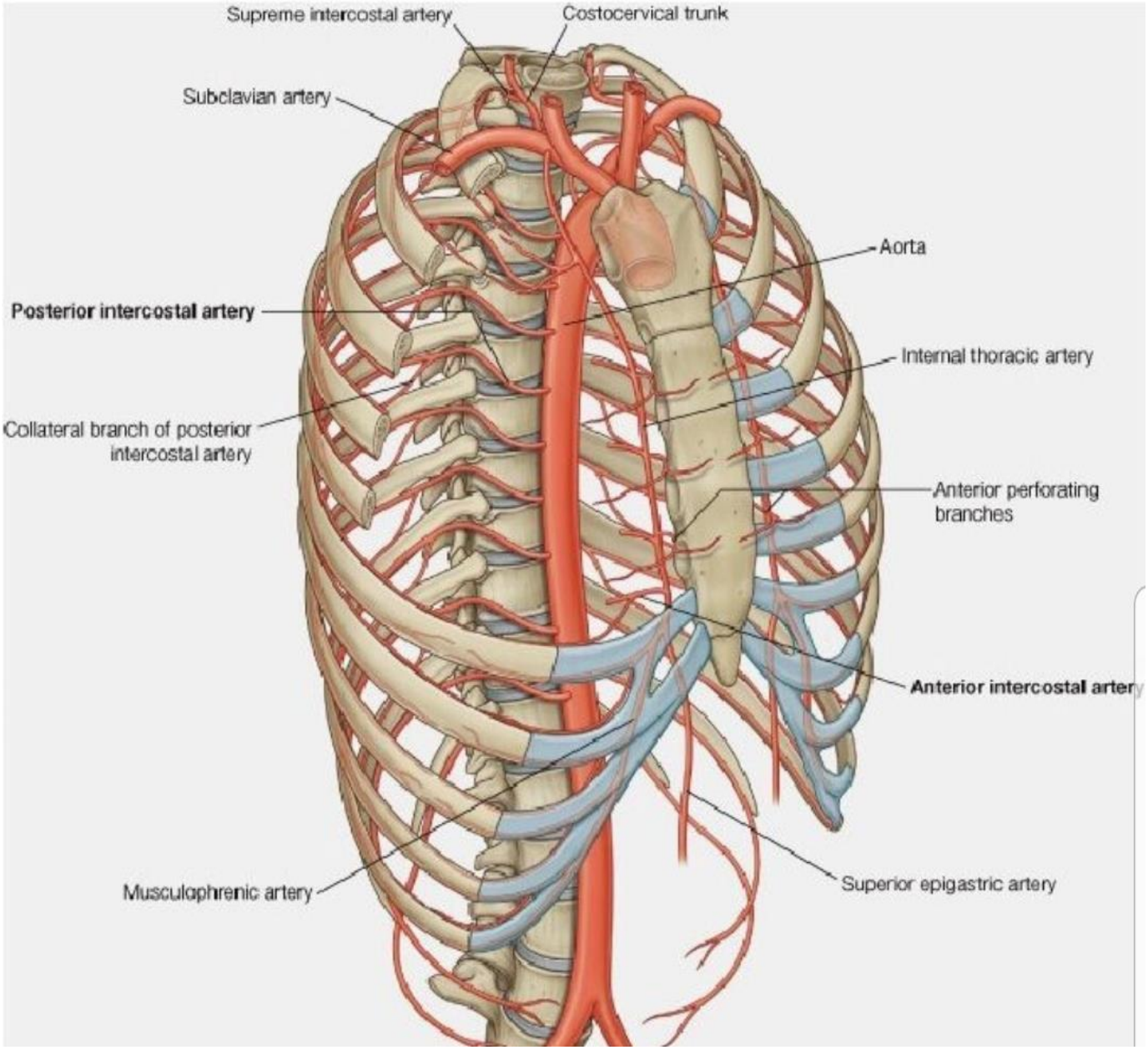
- **Arterial Supply:**
  - Phrenic branches of thoracic and abdominal aorta
  - Pricardiophrenic and Musculophrenic branches of internal mammary artery.
  - Lower 3 posterior intercostal arteries.
- **Nerve Supply:**
  - **Motor**—the phrenic nerves (C3, C4, C5) which supply the diaphragm from its lower surface
  - **Sensory**—lower 6 thoracic nerves.
    - Action—it is the main muscle of inspiration and it increases the intro abdominal pressure.



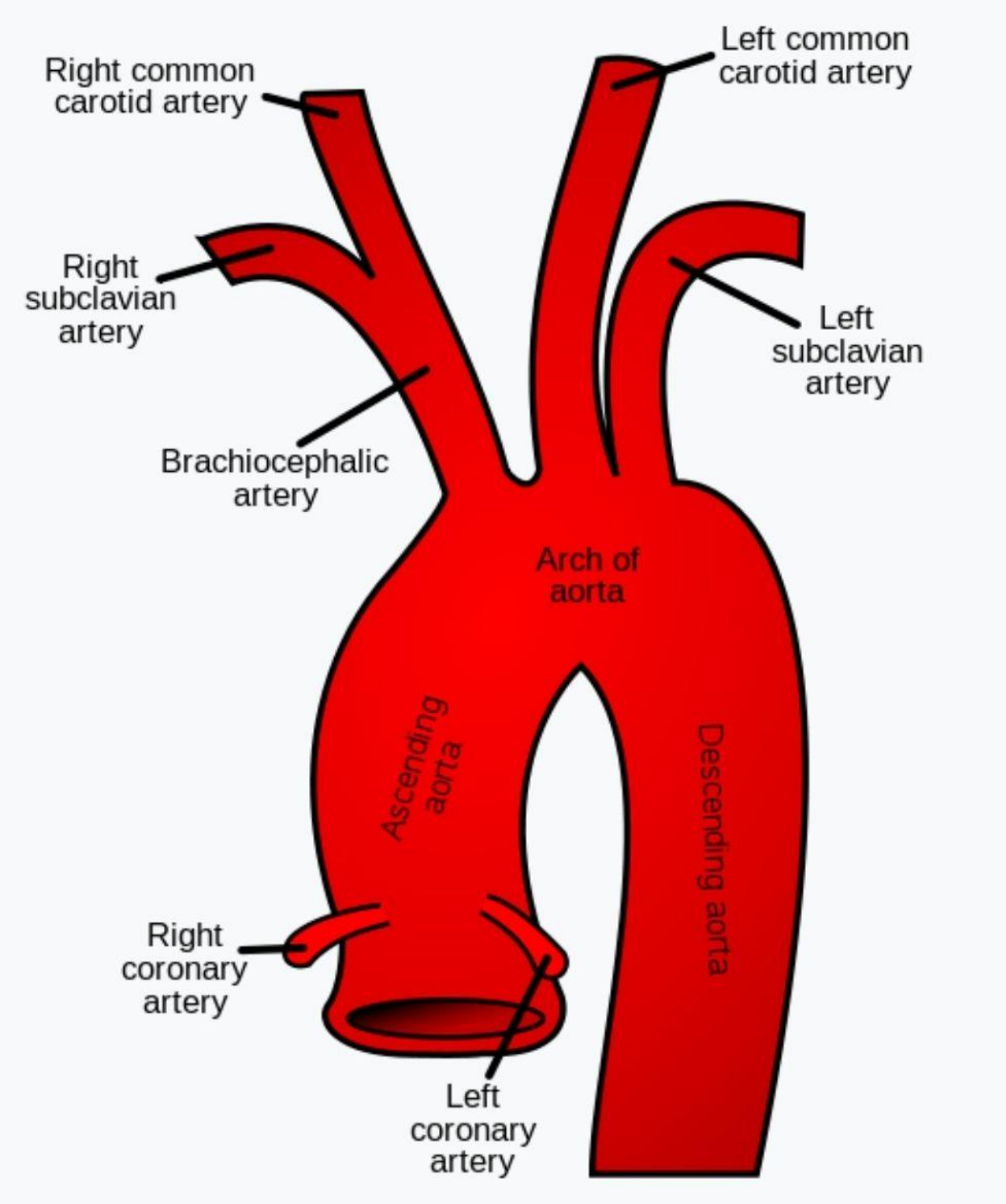
Opening	Vena Caval Opening	Esophageal Opening	Aortic Opening
Vertebral Level	T8	T10	T12
Structures Passing through	• Inferior Vena Cava • Terminal Branches of right phrenic nerve	• Esophagus • Right and Left Vagus nerves • Esophageal branches of left gastric artery and vein.	• Descending Aorta • Thoracic Duct • Azygous Vein

- **Actions of the Diaphragm:**
    - It is the main muscle of inspiration.
    - It increases the intra-abdominal pressure to give additional power to all expulsive actions.
    - It helps the venous return to the heart by increasing the intra-abdominal pressure and decreasing the intra-thoracic pressure.
- **Applied Anatomy:**
    - Hiccough
    - Irritation of the diaphragm
    - Injury of a phrenic nerve
    - Acquired hiatus hernia.

Arteries of the Thorax



Thoracic Aorta



- **The Thoracic Aorta is divided at 3 points:**
  - The Ascending Aorta
  - The Arch of Aorta
  - The Descending Aorta
- **The branches of the Arch of Aorta:**
  - The left common carotid artery
  - The left subclavian artery
  - The brachioceph/alic artery
- **The branches of the Brachiocephalic Artery:**
  - Right common Carotid artery
  - Right subclavian artery

Ascending Aorta

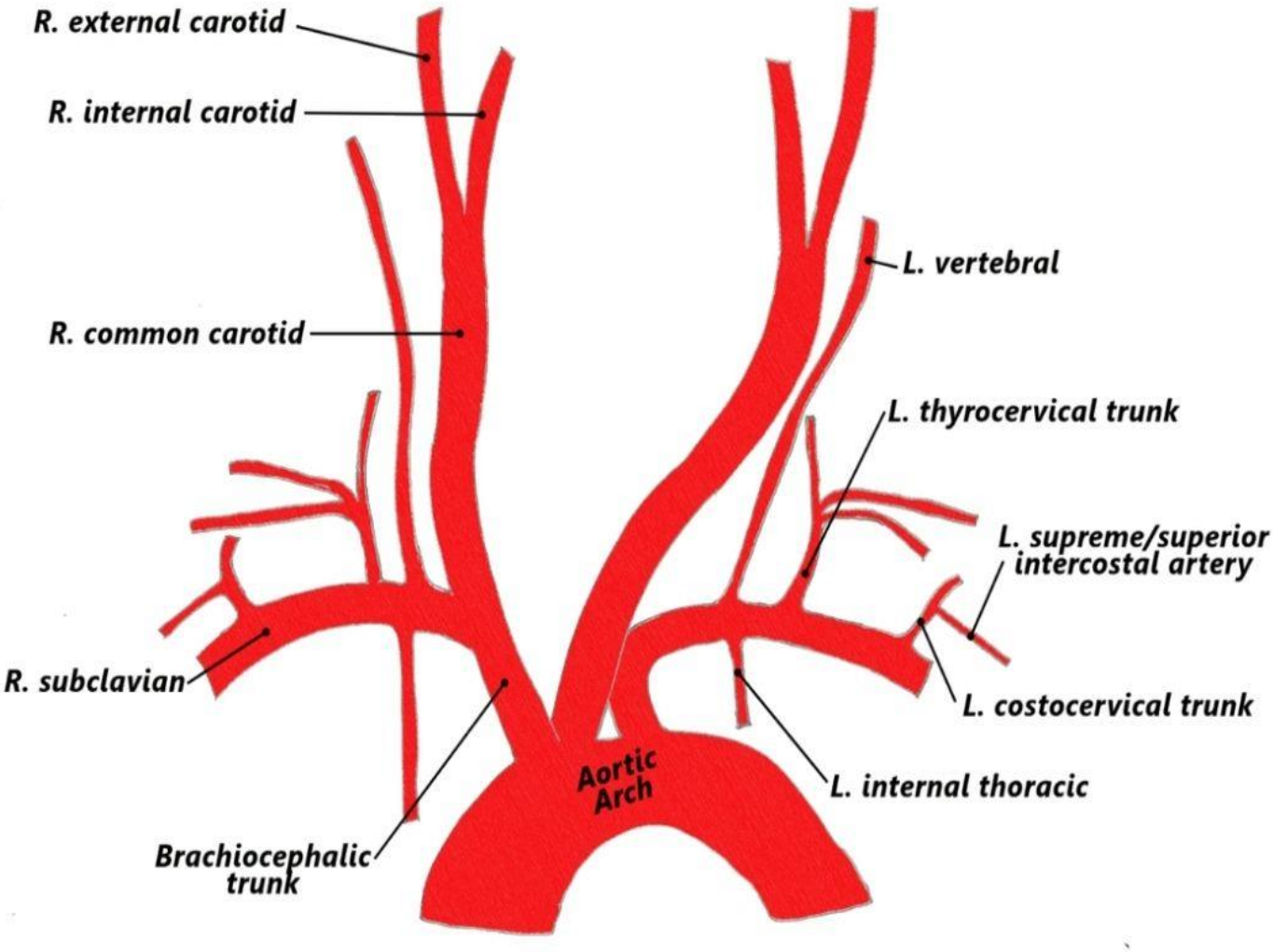
- **Begins:** from the vestibule of the left ventricle behind the left border of the sternum at the level of the left 3rd intercostal space.
- **Ends:** by becoming the arch of aorta behind the right secondary sternocostal junction.
- **Notes:** ascending aorta lies inside fibrous pericardium and has 3 dilations called aortic sinuses.
  - One anterior
  - Two posterior—right and left
- **Branches of the Ascending Aorta:**
  - **Right Coronary Artery**—arises from the anterior aortic sinus.
  - **Left Coronary Artery**—arises from the left posterior aortic sinus.

Descending Thoracic Aorta

- **Begins:** as a continuation of the aortic arch on the left side of the lower border of T4 vertebra.
- **Ends:** by becoming the abdominal aorta at the aortic opening of the diaphragm at the lower border of T12 vertebra.
- **Branches:**
  - Posterior intercostal artery
  - Subcostal arteries
  - 2 left bronchial arteries
  - Esophageal arteries
  - Pericardium, mediastinum and diaphragm muscles.

Arch of Aorta

- **Begins:** as a continuation of the ascending aorta “between the right secondary sternocostal junction”.
- **Ends:** by becoming the descending aorta “on the left side of the disc between T4 and T5”
- **Branches:**
  - Innominate “Brachiocephalic artery”
  - Left common carotid artery
  - Left subclavian artery
  - Thyroid ima artery



Innominate “Brachiocephalic” Artery

- **Begins:** from the aortic arch in front of trachea.
- **Ends:** behind the upper border of right sternoclavicular joint by dividing into right common carotid artery and right subclavian artery.

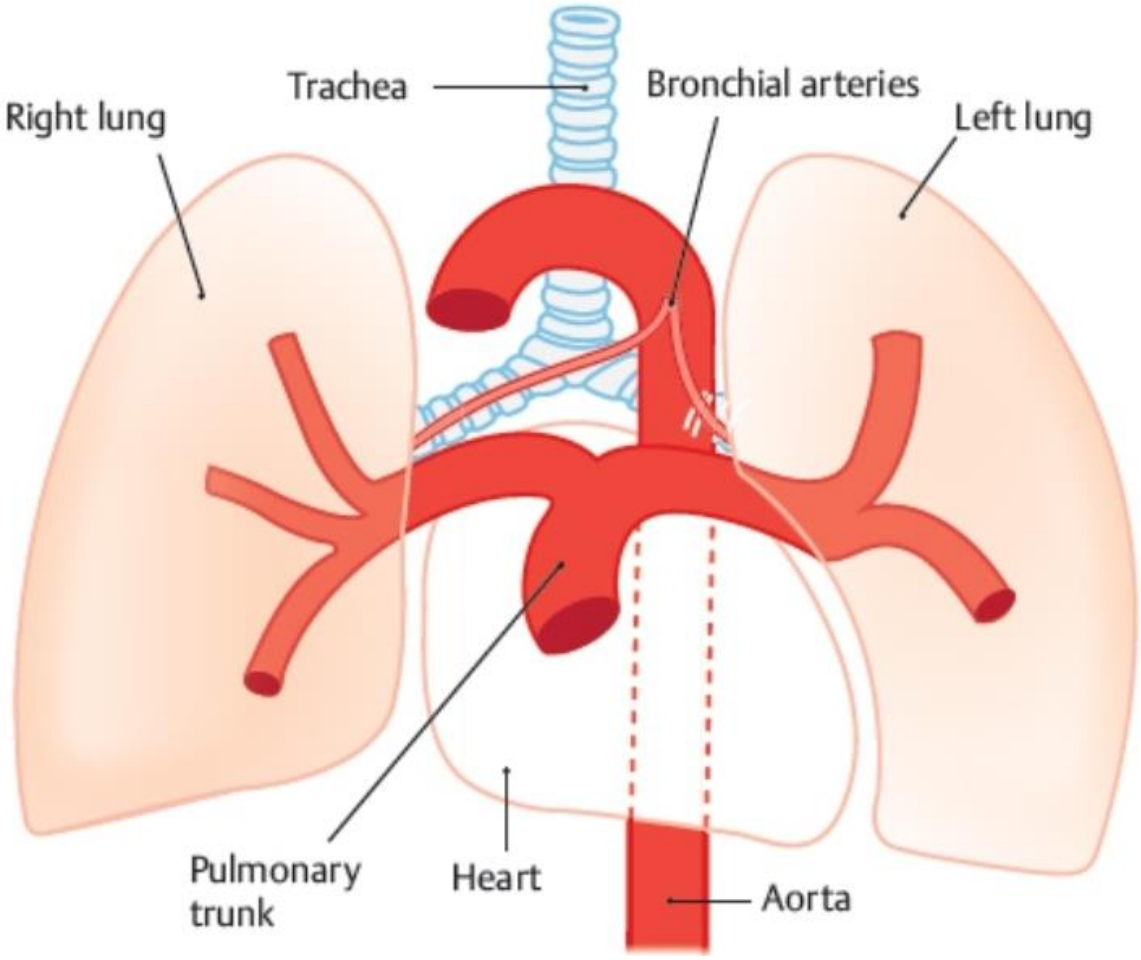
Left Common Carotid Artery

- **Begins:** in front of the trachea, from the arch of aorta just to the left of origin of the brachiocephalic artery.
- **Ends:** continues upwards int eh neck inside the carotid sheath.

Left Subclavian Artery

- **Begins:** from the arch of aorta 1cm behind the origin of the left common carotid artery.
- **Ends:** by becoming axillary artery at the outer border of the 1st rib.

Pulmonary Trunk



- **Definition:** it's a large arterial trunk which transmits non-oxygenated blood from the right ventricle to the lungs.
- **Length:** 5cm long
- **Diameter:** 3cm
- **Begins:** form the summit of the infundibulum of right ventricle behind sternal end of the 3rd left costal cartilage.
- **Ends:** by dividing into right and left pulmonary arteries
    - The bifurcation of pulmonary trunk occurs to the left of the midline just inferior to T4 and T5 vertebra. The anteroinferiorly to the left of bifurcation of the trachea.
- **Course:** passes upwards, backwards and to the left winding around the left side of ascending aorta.

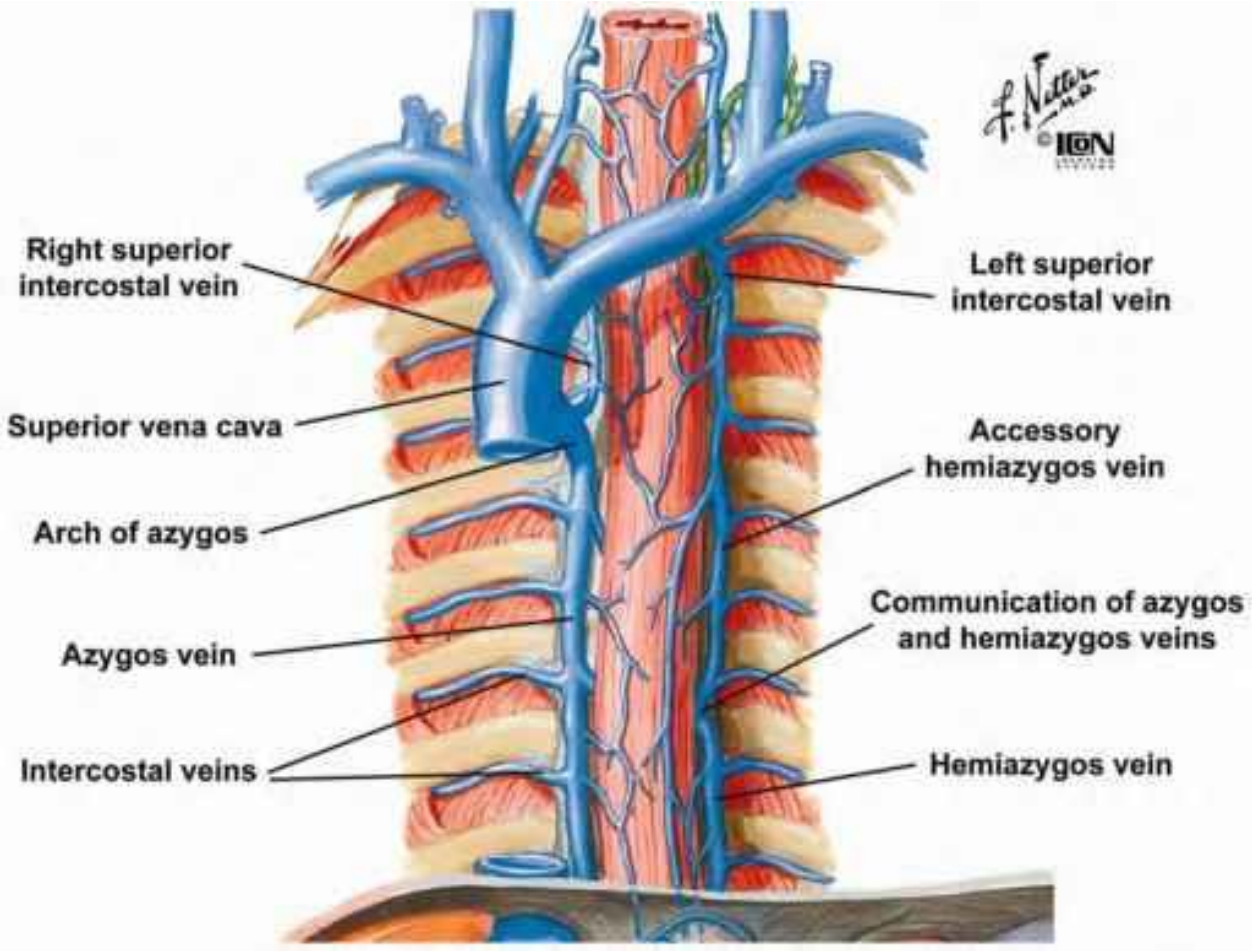
Right Pulmonary Artery

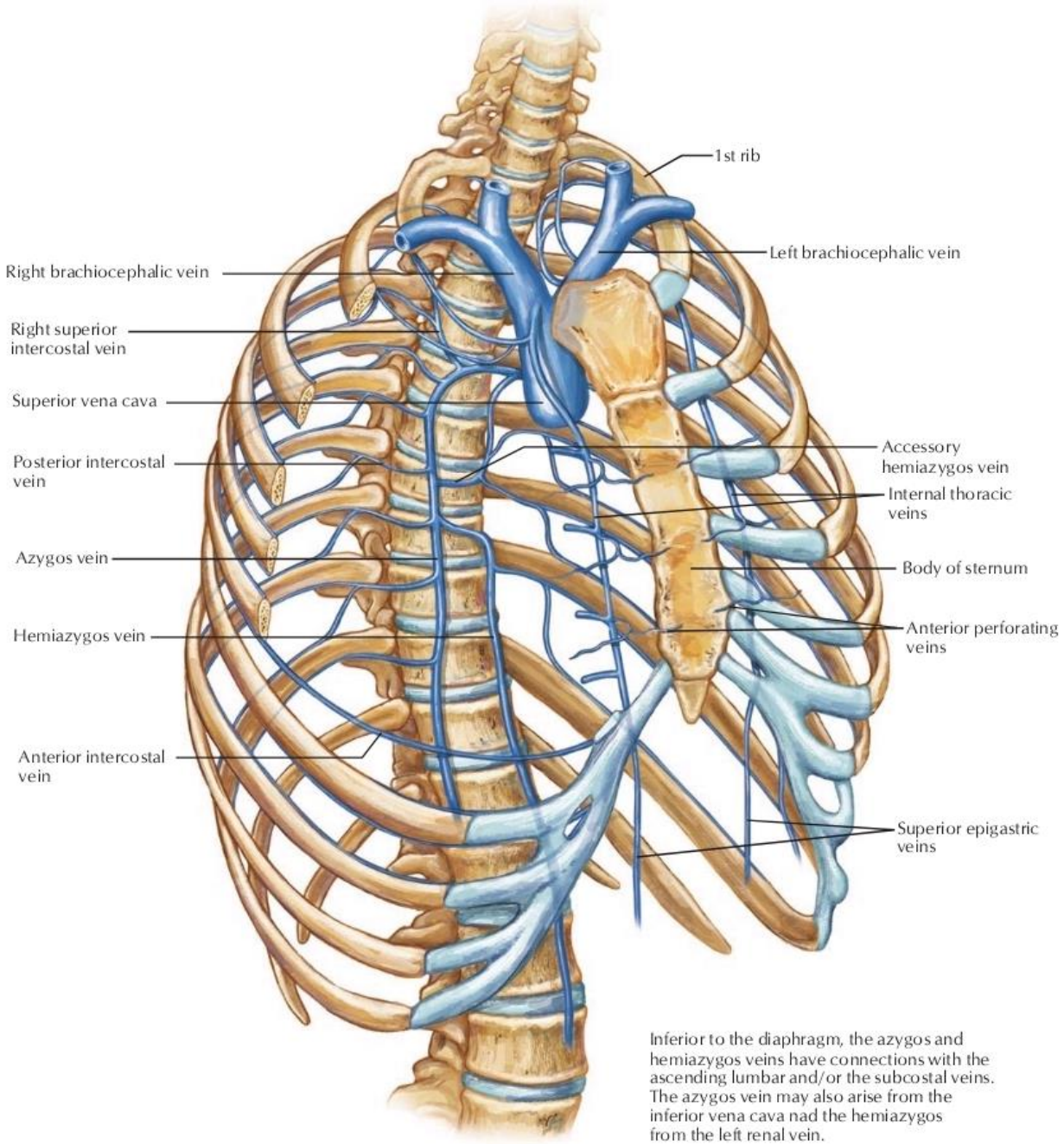
- **Begins:** it arises as the long terminal branch of pulmonary trunk at the lower border of aortic arch between T4 and T5.
- **Ends:** by dividing into 2 branches:
    - A small branch to the superior lobe of the lung
    - A large branch to the inferior and middle lobes of the lung.

Left Pulmonary Artery

- **Begins:** as the shortest terminal branch of the pulmonary trunk at eh lower border of aortic arch between T4 and T5.
- **Ends:** by dividing into 2 branches, one for the upper lobe of the lung, and one for the lower lobe of the lung.
- **Note:** left pulmonary artery connects to the lower surface of the arch of aorta by ligamentum arteriosum.

The Veins of the Thorax





Inferior to the diaphragm, the azygos and hemiazygos veins have connections with the ascending lumbar and/or the subcostal veins. The azygos vein may also arise from the inferior vena cava nad the hemiazygos from the left renal vein.

Right Brachiocephalic Vein

- **Begins:** behind the medial endo f right clavicle by union of right internal jugular vein and the right subclavian vein.
- **Ends:** by uniting with the left brachiocephalic vein behind the right border of sternum opposite the lower border of 1st right costal cartilage to form superior vena cava.
- **Length:** about one inch long.
- **Tributaries:**
  - **From the neck**
    - Right vertebral vein
    - Right inferior thyroid vein
  - **From the thorax**
    - Right inferior mammary vein
    - Right 1st posterior intercostal vein
    - Right lymphatic duct

Left Brachiocephalic Vein

- **Begins:** behind the medial end of the left clavicle by union of the left internal jugular vein and left subclavian vein.
- **Ends:** by uniting with the right brachiocephalic vein behind the right border of sternum opposite the lower border of 1st right costal cartilage to form superior vena cava.
- **Length:** about 3 inches long.
- **Tributaries:**
  - **Form the neck:**
    - Left vertebral vein
    - Left inferior thyroid vein
  - **From the thorax:**
    - Left inferior mammary vein
    - Left 1st posterior intercostal vein
    - Left superior intercostal vein
    - Left lymphatic duct.

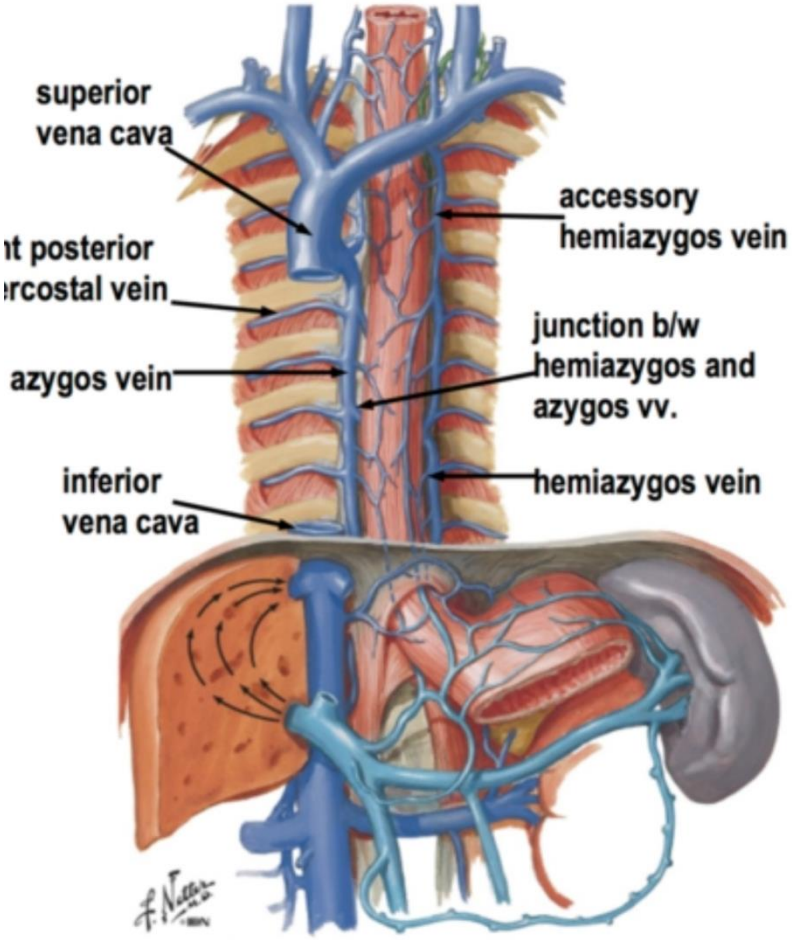
The Superior Vena Cava

- **Begins:** by the union of right and left brachiocephalic vein, behind the lower border of right 1st costal cartilage close to the sternum.
- **Ends:** behind the right 3rd sternocostal junction, by opening into the right atrium.
- **Length:** about 2 inches long.
- **Tributaries:** the arch of Azygos.
- **Note:** the superior vena cava drains the venous blood of the upper ½ of the body.

The inferior Vena Cava

- **Begins:** by piercing the central tendon of the diaphragm opposite T8 vertebra.
- **Ends:** by opening into the lower part of the right atrium opposite the 6th right sternocostal junction.

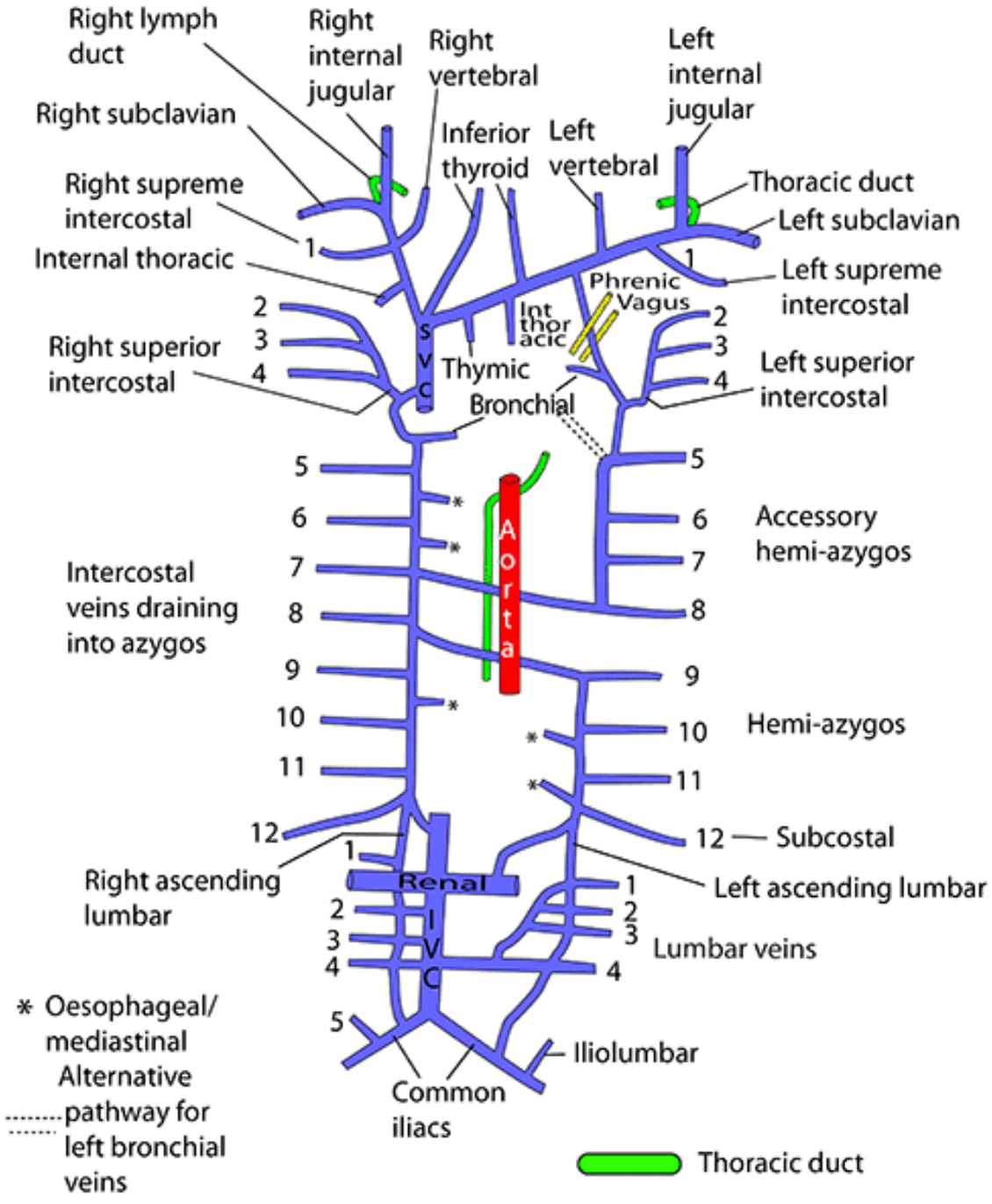
Azygous Vein



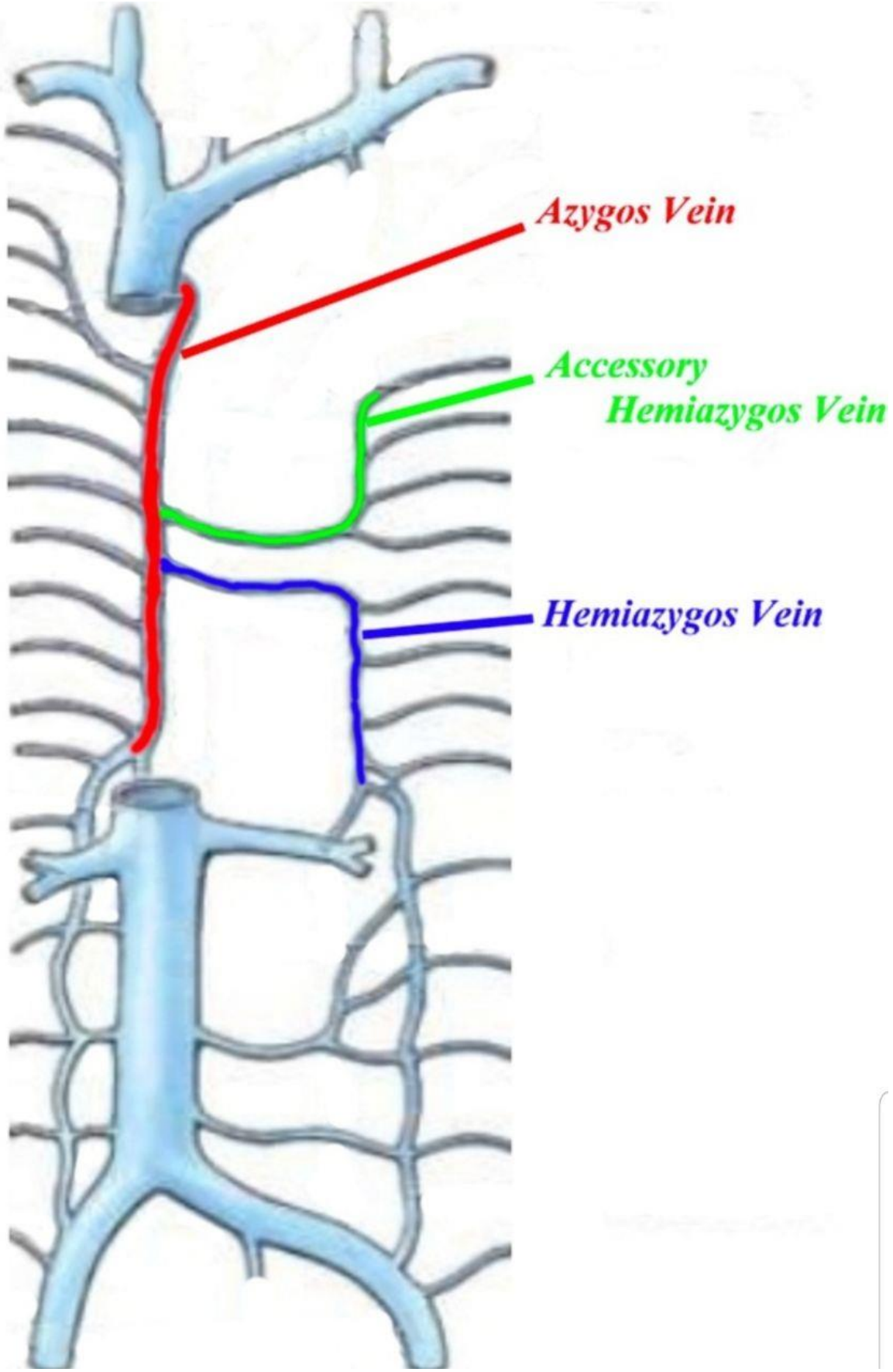
- **Begins:** in the abdomen form the back of the inferior vena cava at the level of renal vein L2.
    - May be between the diaphragm and the body of T12.
    - By union of right subcostal and right ascending lumbar veins.
- **Ends:** in the back of the superior vena cava opposite the 2nd right costal cartilage.
- **Courses:**
    - In the posterior mediastinum—it ascends on the right side of the bodies of lower 8 thoracic vertebrae behind eh esophagus, and root of right lung.
    - In the superior mediastinum (arch of azygous)—it makes an arch from behind forward above the root of right lung crossing the sides of the esophagus, right vagus nerve and trachea.

- **Tributaries:**
    - Right ascending lumbar vein
    - Right subcostal vein
    - Superior hemiazygos vein
    - Inferior hemiazygos vein
    - Right posterior intercostal veins from 5 to 11
    - Bronchial veins from the right lung
    - Right superior intercostal vein
    - Some esophageal and pericardial and diaphragmatic veins.

SUPERIOR VENA CAVA AND AZYGOS SYSTEMS



Note: Left and right supreme intercostal veins may drain into vertebral veins


Azygos Vein
Accessory
Hemiazygos Vein
Hemiazygos Vein

Inferior Hemiazygos Vein

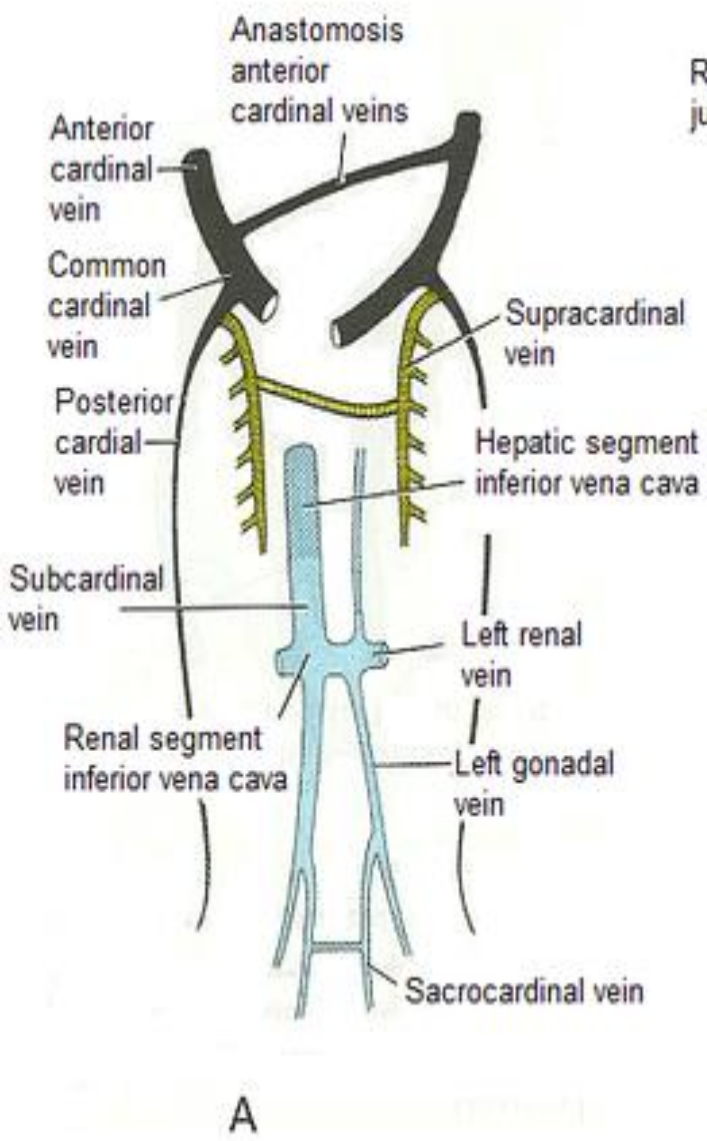
- **Begins:** from the back of left renal vein L2 vertebra in the abdomen by union of left subcostal and ascending lumbar veins.
- **Ends:** in the azygos vein
- **Tributaries:**
  - Subcostal Vein
  - The 11^{th},10^{th} and 9^{th} posterior intercostal veins of left side.

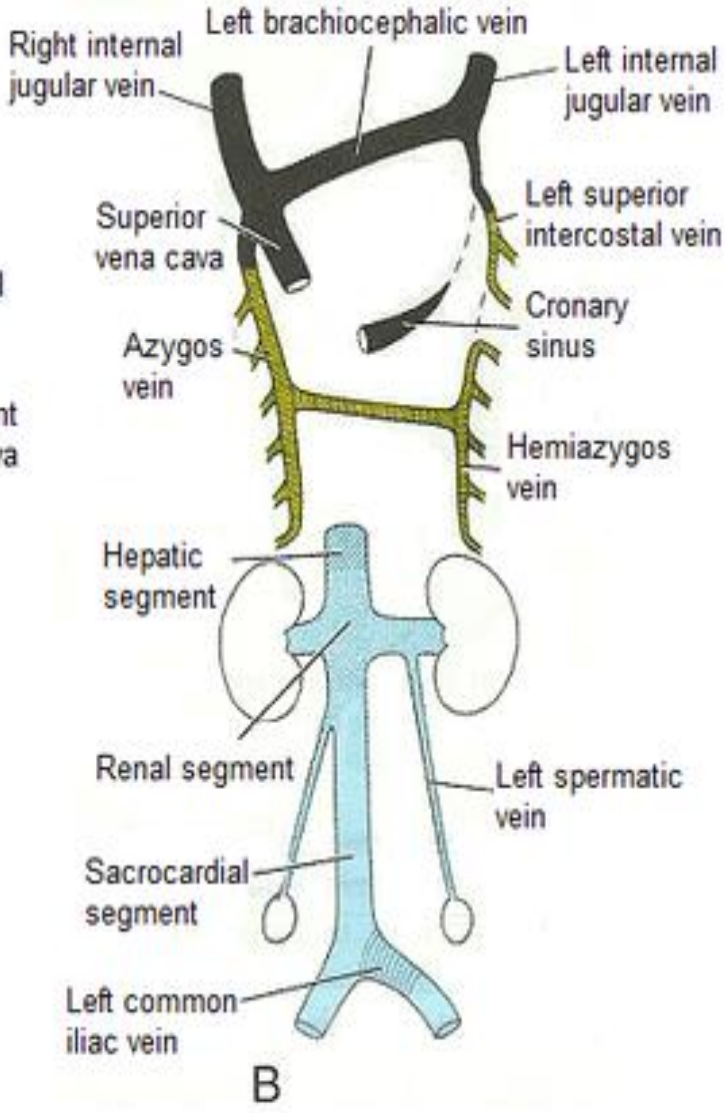
Superior Hemiazygos Vein

- Begins: at the posterior end of the 5^{th} left intercostal space as continuation of the 5^{th} posterior intercostal vein.
- Ends: in the azygos vein.
- Tributaries:
  - 5^{th}, 6^{th}, 8^{th} left posterior intercostal veins.

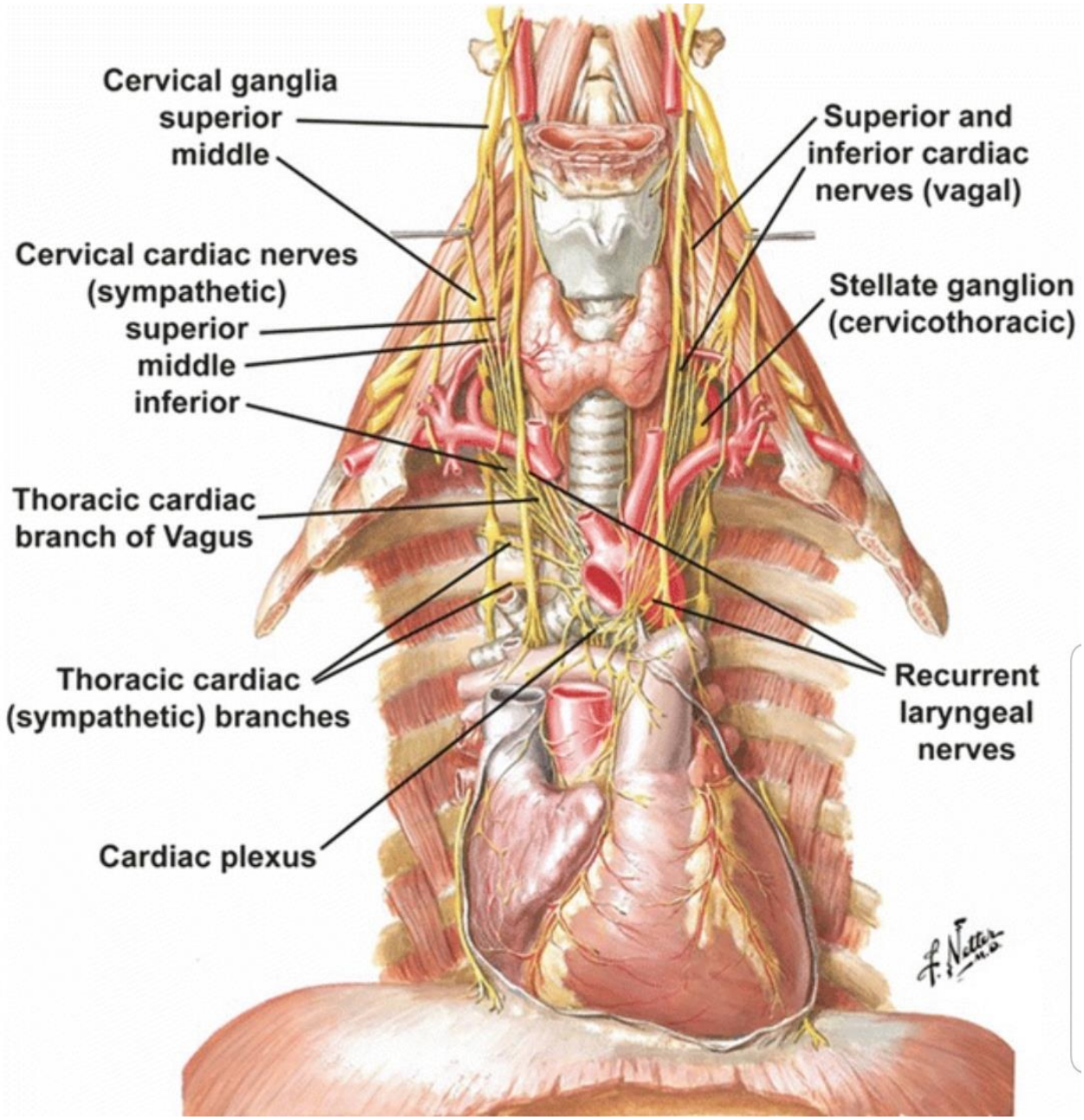
Anastomosis between Superior Vena Cava and Inferior Vena Cava

- Anterior abdominal wall—superior epigastric vein of mammary vein with inferior epigastric vein of external iliac vein.
- Posterior abdominal wall:
  - Azygos vein arises from the back of the inferior vena cava and ends in the back superior vena cava.
  - Inferior Hemiazygos vein





- # Nerves of the Thorax



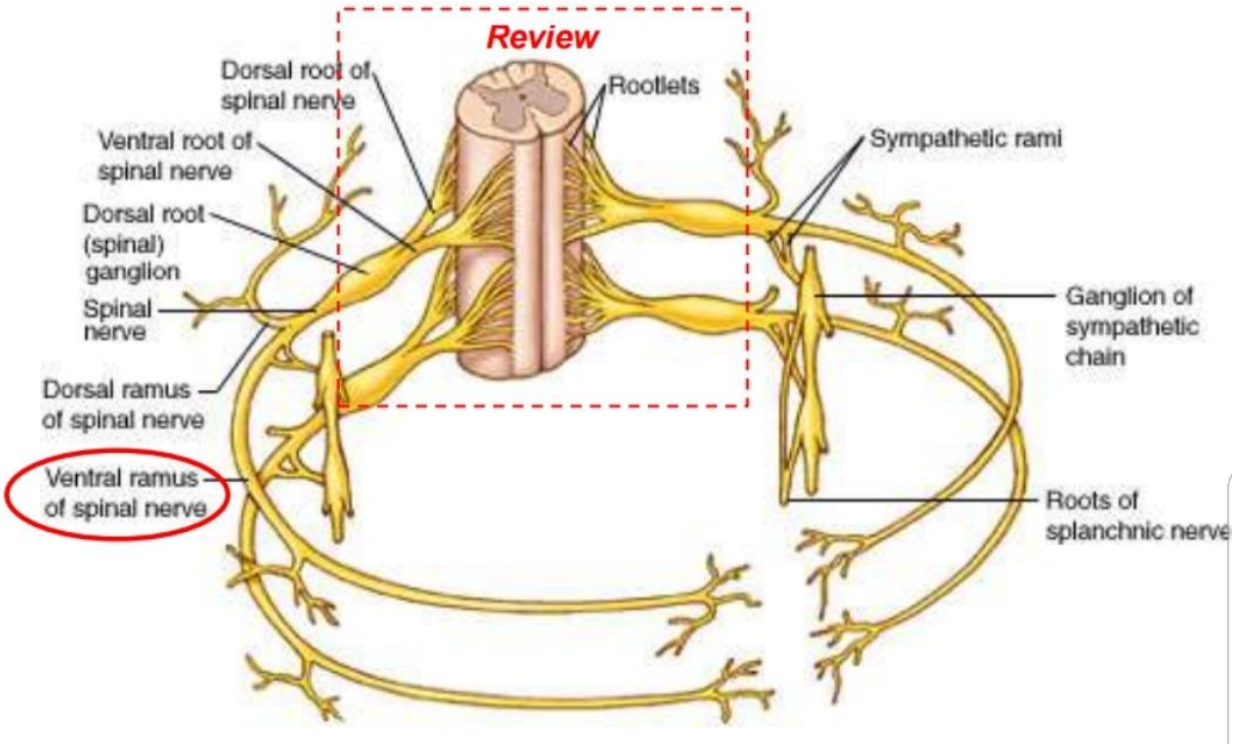
Phrenic Nerves

- **Type:** mixed nerve, motor to the diaphragm and sensory to the serous membranes.
- **Origin:** in the neck from cervical plexus “anterior primary rami of C3,C4,C5, but mainly C4”
- **Distribution of Phrenic Nerve:**
  - **Motor**—to the diaphragm “its the only motor nerve which supplies diaphragm”
  - **Sensory:**
    - To pericardium
    - Pleura “mediastinal and diaphragmatic”
    - Peritoneum lining the abdomen’s surface of diaphragm
    - Right phrenic nerve also supplies the gallbladder.
  - Phrenic nerve is divided into right and left phrenic nerves.
  - The right phrenic nerve leaves the thorax through the vena caval opening of the diaphragm.
  - The left phrenic nerve leaves the thorax through a special opening the left cupola of diaphragm.
- **Note:**
  - The phrenic nerve is shorter than the left phrenic because:
    - The right cupola of the diaphragm is higher than the left.
    - The right side of the pericardium is straight.

Vagus Nerve

- **Type:** mixed in parasympathetic, motor and sensory.
- **Origin:** it's the 10th cranial nerve and it arises from the medulla.
  - It's the longest cranial nerve.
  - **Note:** vagus nerve, is the most important parasympathetic nerve int eh body as it supplies parasympathetic fibers to:
    - Respiratory tube
    - The digestive tube and glands from esophagus to the left colic flexure.
    - The heart "atria"
  - Vagus nerve divided into right and left Vagi nerve.
- **Branches of the Vagi in the thorax:**
  - Cardiac branches
  - Left recurrent laryngeal nerve
  - Posterior pulmonary branches
  - Anterior pulmonary branches
  - Esophageal branches

Thoracic Part of the Sympathetic Chain



- **Entrance into Thorax:**
  - Each sympathetic chain enters the thorax by crossing in front of the neck of the 1st rib.
- **Exit from the Thorax:**
  - Each sympathetic chain leaves the thorax by passing behind the mid-arcuate ligament of diaphragm to enter the abdomen.
- **Note:**
  - The 2 sympathetic chains descend paravertebrally (on each side of the vertebral column) first in the superior mediastinum then in the posterior mediastinum.
  - Each sympathetic chain is covered by the parietal pleura (costal pleura) throughout its whole course in the thorax.
  - The Thoracic part of each sympathetic chain carries 11 or 12 ganglia.
- **Stellate Ganglion**—formed by the 1st thoracic ganglion may unite with the inferior cervical ganglion.

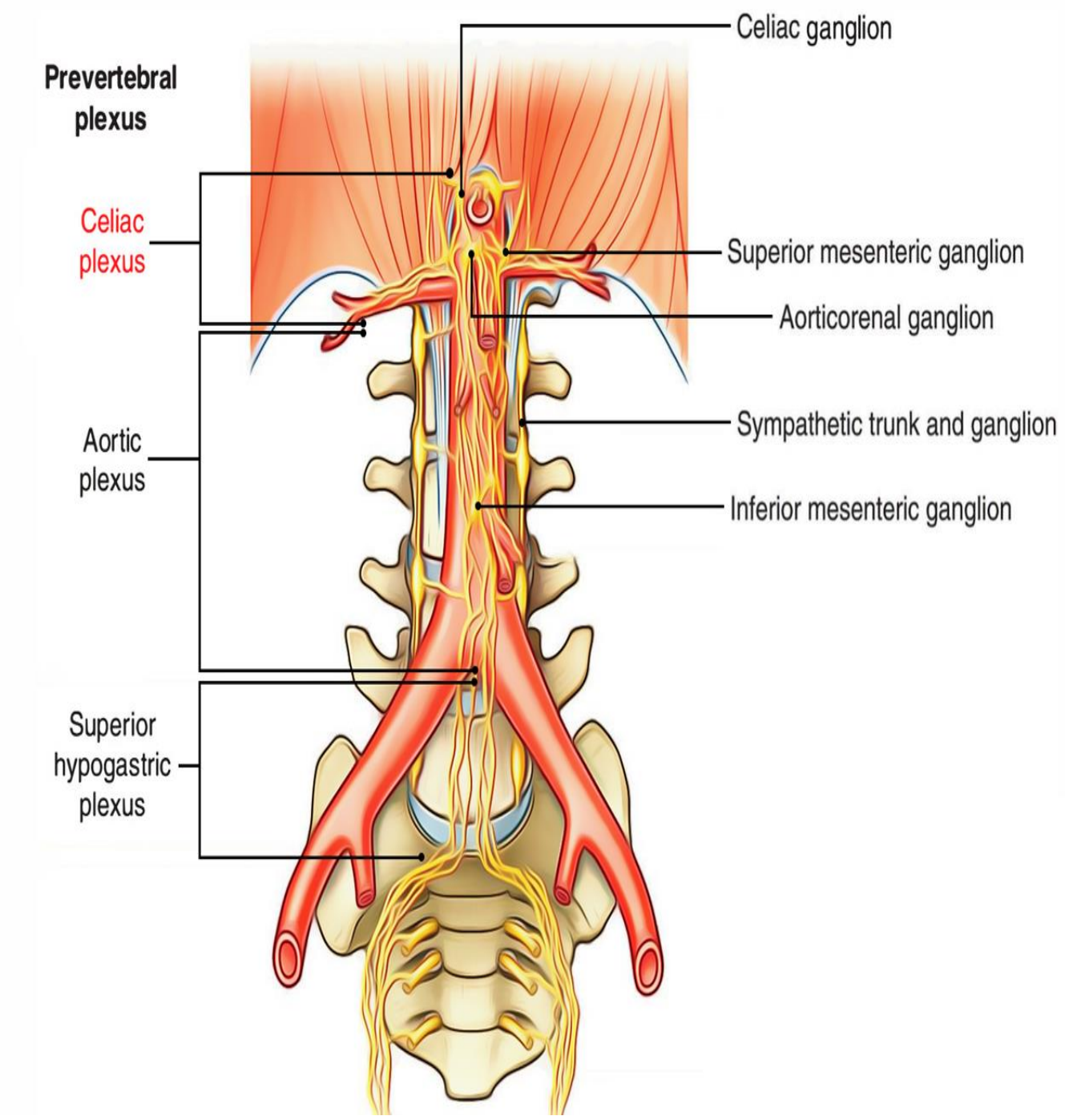
- **Branches:**
  - **Lateral Communicating Branches toe the Spinal Nerves:**
    - White Ramus Communicans—carrying preganglionic sympathetic fibers to spinal nerve.
    - Grey Ramus Communicans—carrying postganglionic sympathetic fibers to spinal nerve.
  - **Medial Visceral Branches:**
    - Branches form the upper 5 ganglia—carrying post ganglionic sympathetic fibers to the aortic and Esophageal plexus.
    - Branches from the 2^{nd}, 3^{rd}, and 4^{th} ganglia—carrying post ganglionic sympathetic fibers to cardiac and pulmonary plexuses.
  - **Greater Splenic Nerve:**
    - **Begins:** it arises from the 5^{th}-8^{th} ganglia
    - **Ends:** in abdomen by joining the Coeliac and aortic-renal ganglia.
  - **Lesser Splenic Nerve:**
    - **Begins:** it arises from the 9^{th} and 10^{th} ganglia
    - **Ends:** in the coeliac plexus.
  - **Last (lowest) Splenic Nerve:**
    - **Begins:** arising from the 12^{th} ganglion
    - **Ends:** in the renal plexus around the Renal artery.

Additional Notes:

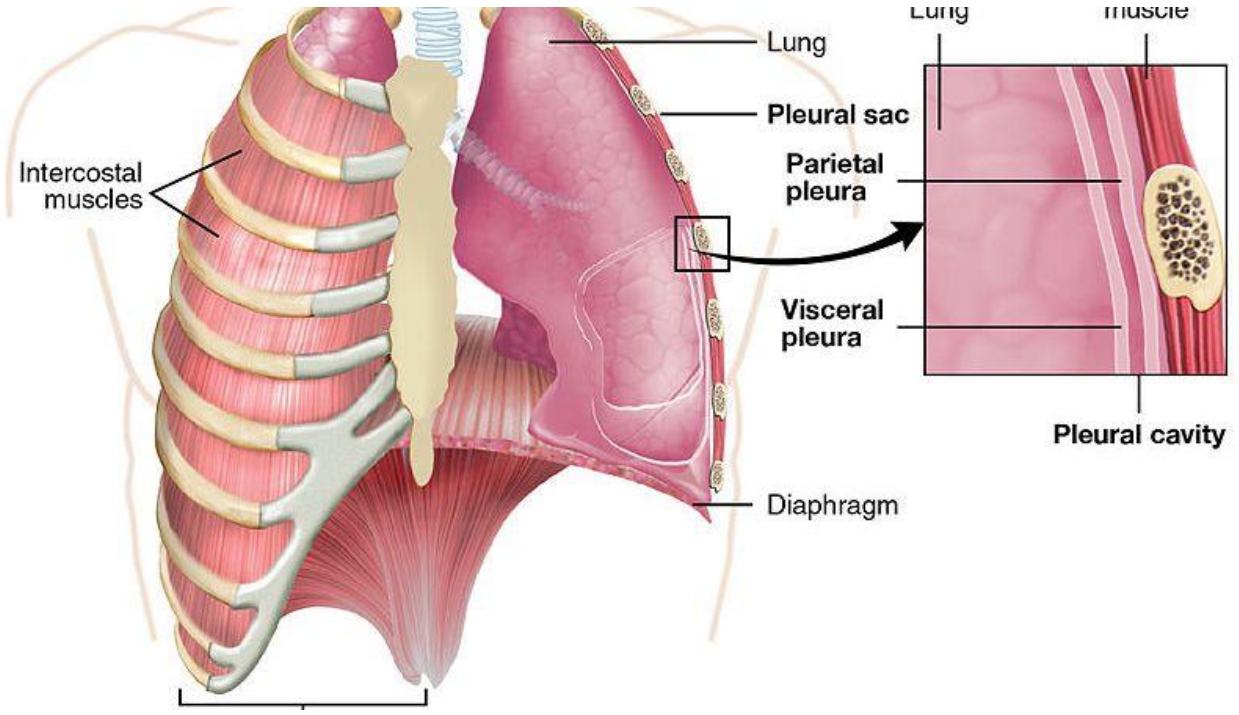
- **Lines of Demarcation of Thorax:**
  - Midsternal Line
  - Mid-Clavicular Line
  - Anterior Axillary Line
  - Posterior Axillary Line
  - The Scapular Line
  - Mid-Axillary Line
- **The Levels of Planes of the Thorax:**
  - **The Plane of the Inlet of Thorax:**
    - Extended from the upper border of manubrium to the upper border of the body of the 1st thoracic vertebra.
  - **The Manubrium:**
    - Lies opposite T3 and T4 vertebrae.
  - **The Plane of Sternal Angle:**
    - Extended from the lower border of manubrium to the lower border of T4 vertebra.
  - **The body of Sternum:**
    - Lies opposite T5-T8 vertebrae.
  - **The Xiphoid Process:**
    - Lies opposite T9 vertebra.

Aortic Plexuses

- **Site:** the aortic plexuses lie around the aorta.
- **Formation:** the aortic plexuses are formed by the sympathetic fibers mainly from the upper 5 thoracic ganglia.

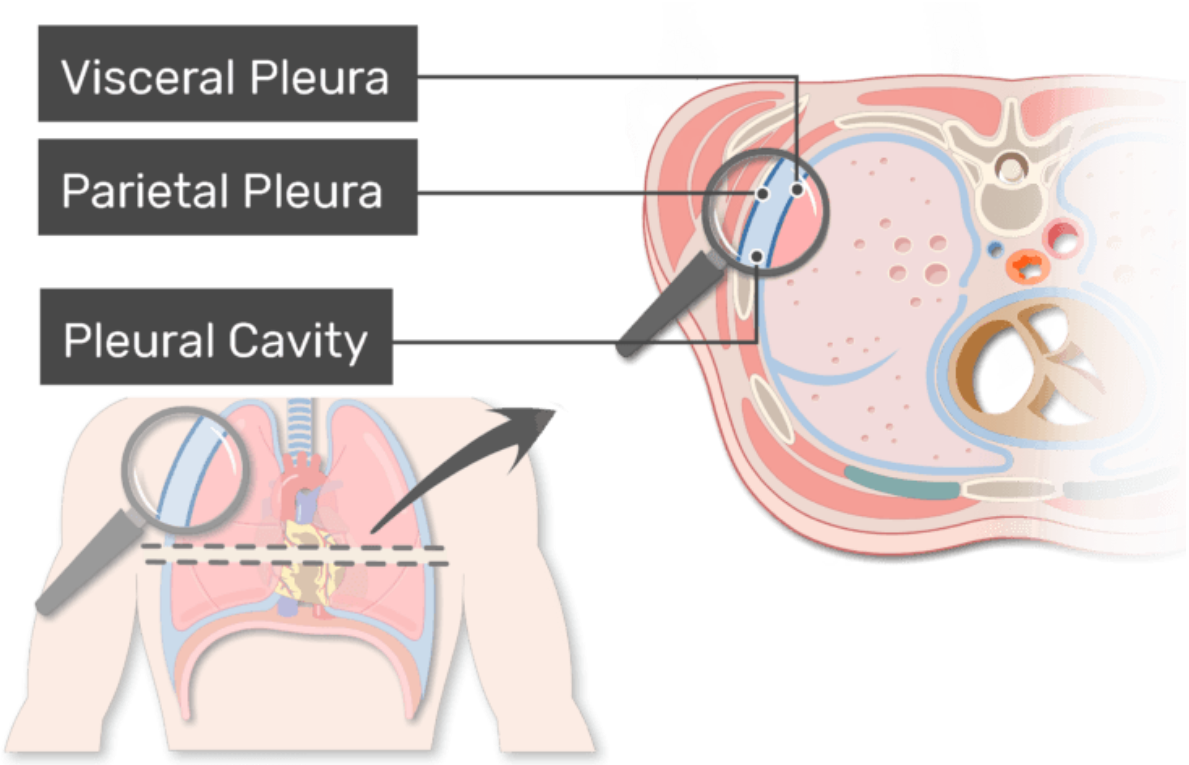


The Pleura

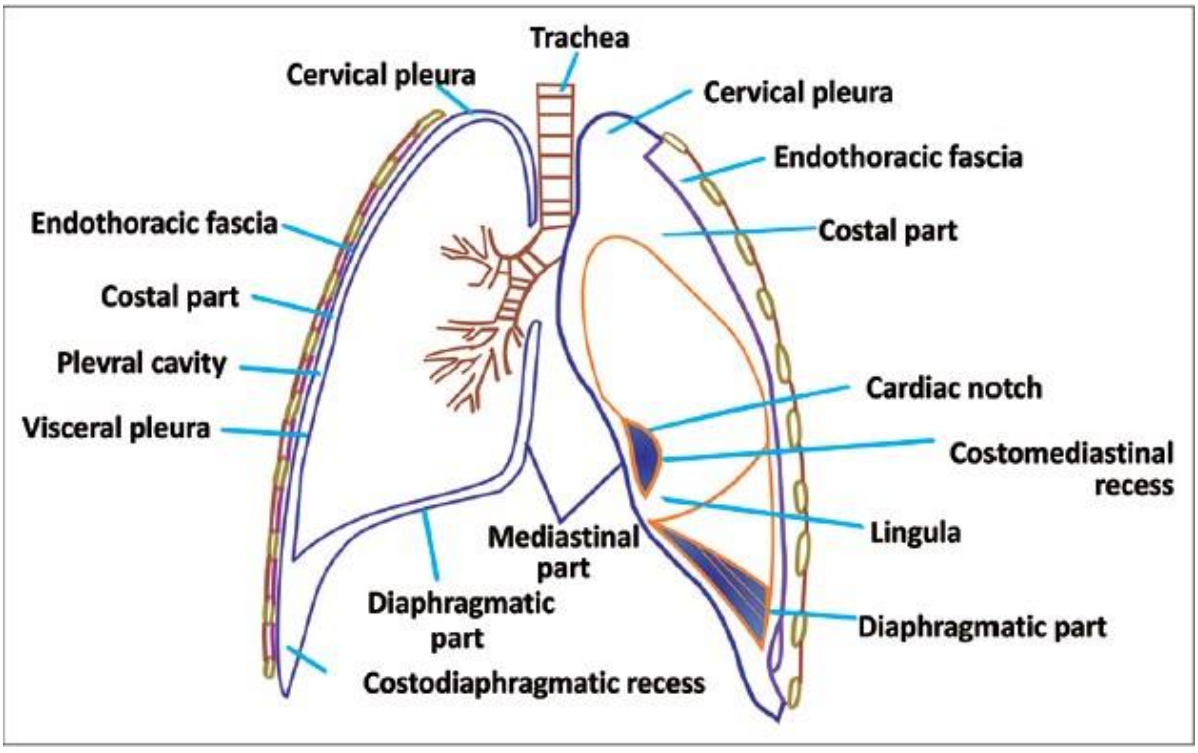


- **Definition:** it's a serous membrane lined by mesothelium surrounding the lungs.
  - **Outer covering of the lung**
  - There are 2 sacs of pleura, one for each of the 2 lungs.
  - **The Pleurae Consists of 2 layers:**
    - An outer layer called the parietal pleura—associated with the walls of the pleural cavity.
    - An inner layer called the visceral/pulmonary pleura—which adheres to and covers the lungs.
- **Extensions:**
  - **Superiorly:**
    - Extends from above the 1st rib into the root of the neck.
  - **Inferiorly:**
    - Extends to the level just above the costal margin.
  - **Medial Wall:**
    - Is the mediastinum

- **Pleural Cavity:** it's the potential space between the visceral and parietal layers of the pleura.
    - **Function:** contains a small volume of serous fluid which provides lubrication, allowing the pleurae to slide over one another without friction. It also produces surface tension pulling the parietal and visceral pleurae together ensuring that when the thorax expands so do the lungs.

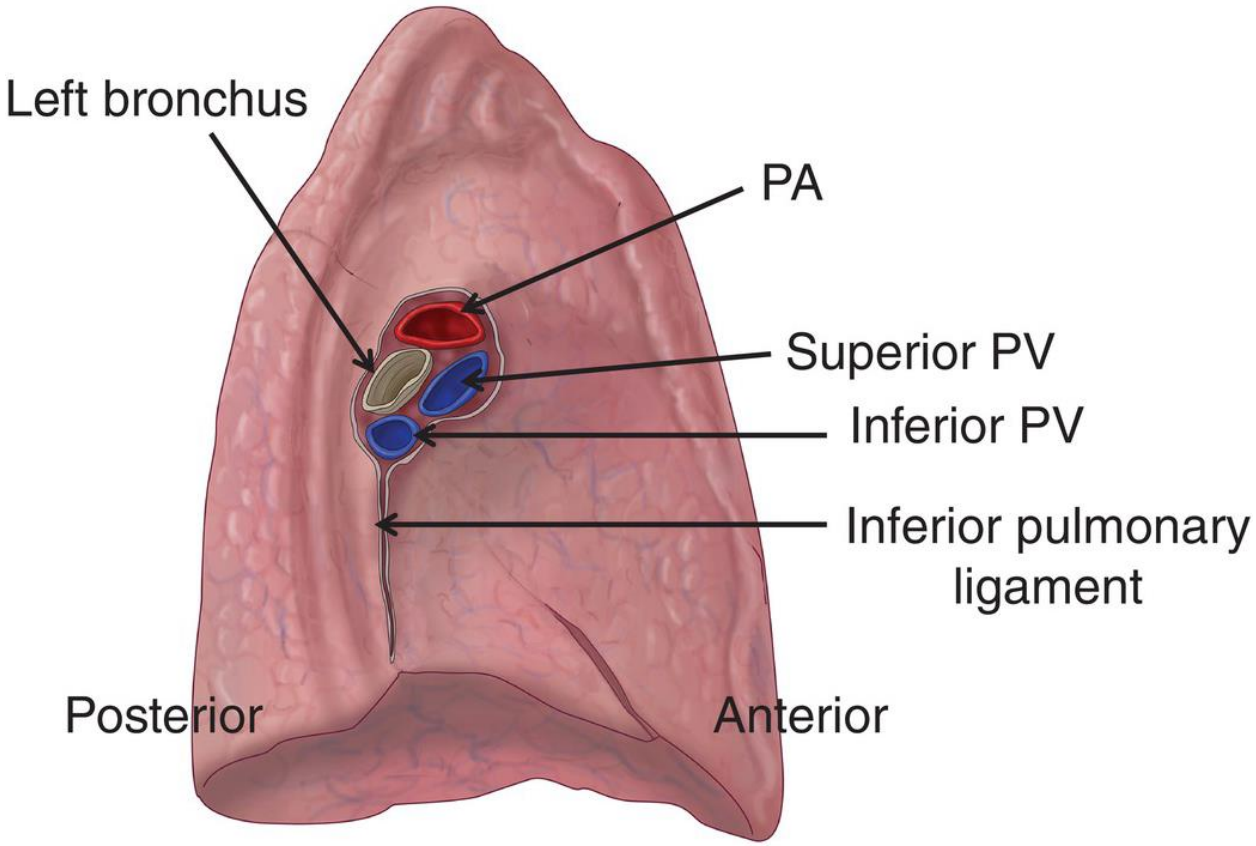


- **The Parietal Pleura**
  - **Definition:** it's thicker than the visceral pleura and it's subdivided into:
    - **Costal part**—lines the thoracic wall (ribs, cartilage, intercostal muscles and spaces) which it loosely attaches to by a layer of areolar tissue called the endothoracic fascia.
    - **Diaphragmatic part**—lines the superior aspect of the diaphragm.
      - Covers the base of the lungs
      - Medially—it is continuous with mediastinal pleura
      - Laterally—it is continuous with the costal pleura
    - **Mediastinal part**—lines the lateral aspect of the mediastinum.
    - **Cervical part**—lines the extension of the pleural cavity into the neck.
      - **Suprapleural membrane**—it's a dome-like layer of fascia found in the superior surface of the cervical pleura. It provides the apical cervical pleura support in the root of the neck.
- **Note:** The cervical part is also referred to as "dome of pleura" or "pleural cupola".



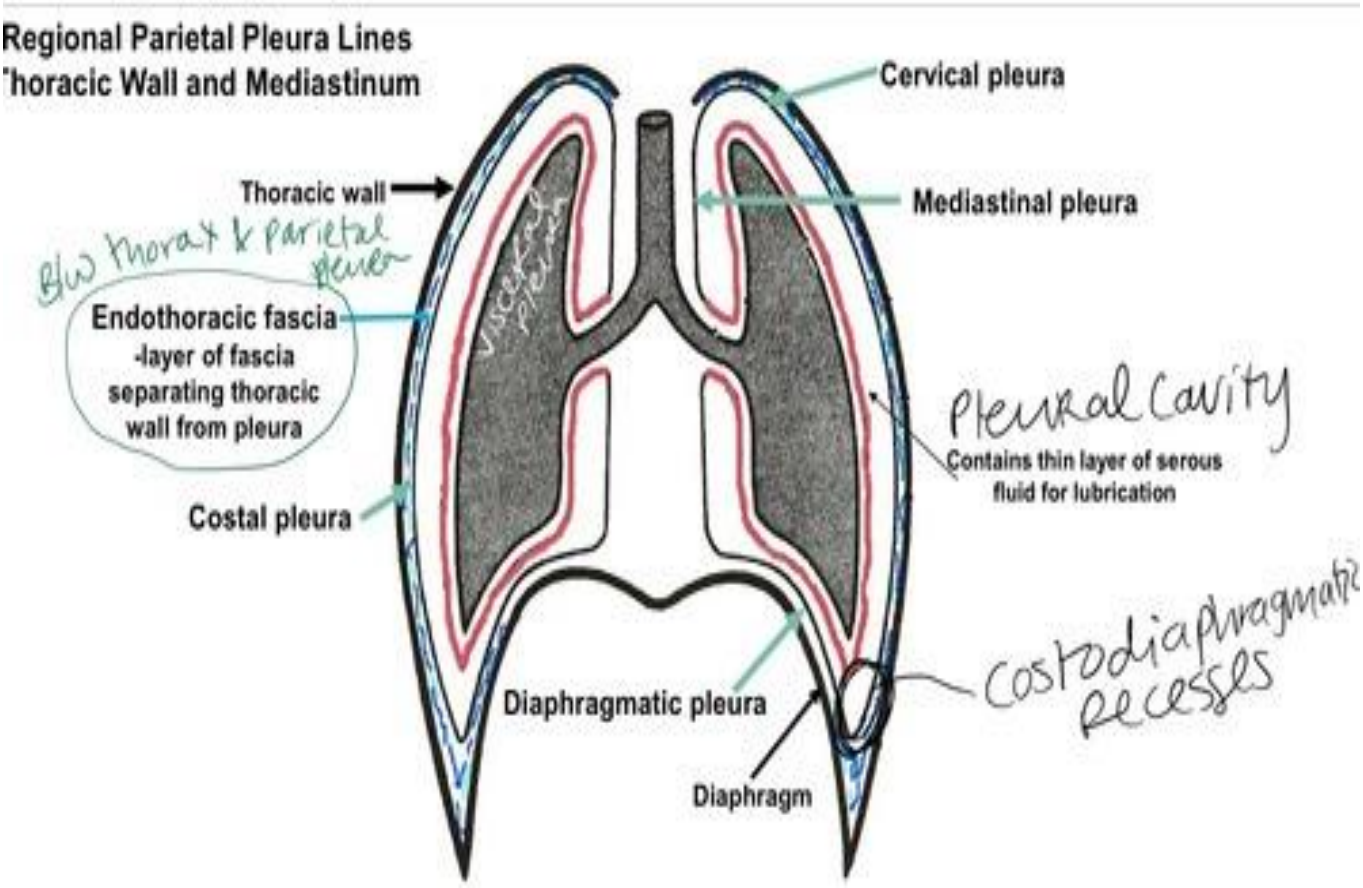
- **The Visceral/Pulmonary Pleura:**
    - **Definition:** it covers the surfaces and fissures of the lung except at the hilum and along the attachment of the pulmonary ligament where it's covered by the parietal layer.
        - It can not be separated from the lung.
- **Pulmonary Ligament**—it is a fold of parietal pleura that surrounds the root of the lung and extends downwards beyond the root.
    - **Contains:**
        - A thin layer of loose areolar tissue
        - Few lymphatics
    - **Function:** provides a dead space into which the pulmonary veins can expand during increased venous return.

(b)



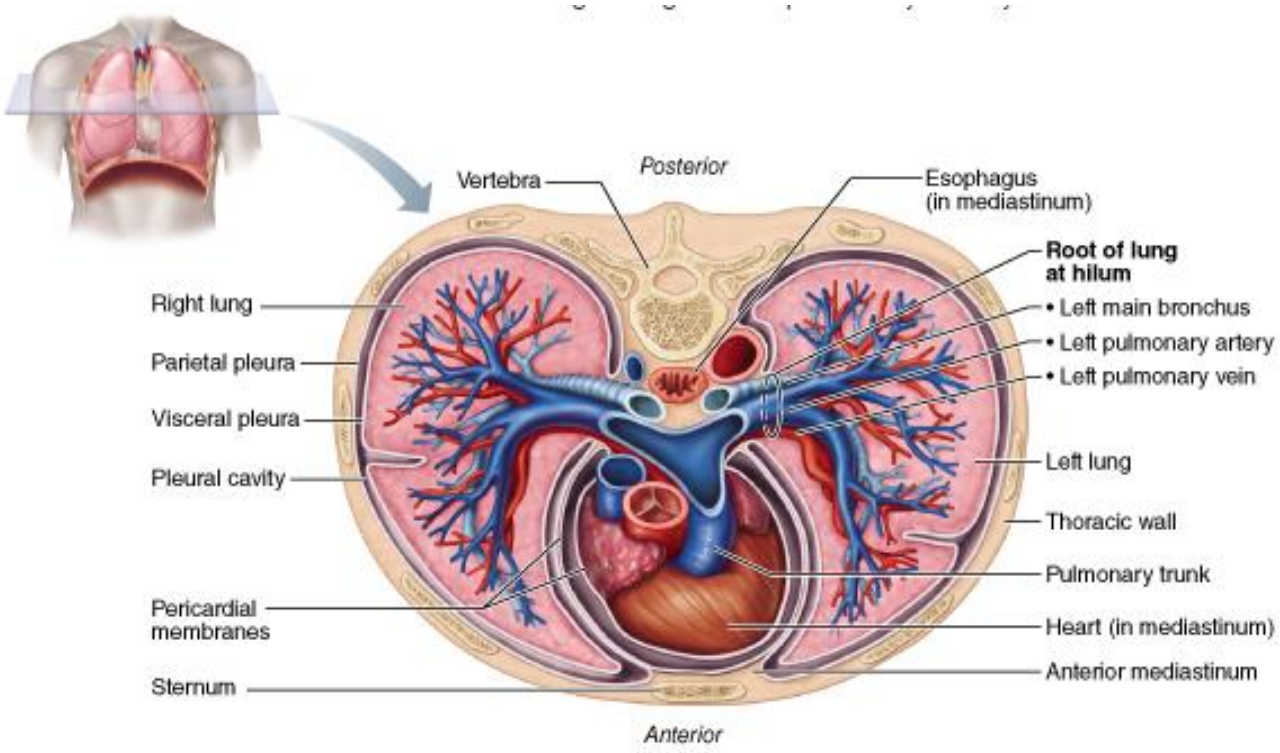
Recesses of Pleura—they act as “reserve spaces” for the lung to expand during deep inspiration. The recesses also provide potential spaces in which fluids can collect and from which fluids can be aspirated (the process in which fluid can be drawn off using a needle and syringe)

- **Costomediastinal Recess**
  - **Location:** lies anteriorly between the costal and mediastinal pleurae, behind the sternum and costal cartilages.
- **Costodiaphragmatic Recess**
  - **Location:** lies inferiorly between the costal and diaphragmatic pleura.
  - **Extension:** from the 8th to the 10th rib.



- **Blood Supply**
  - **The Parietal Pleura**
    - Is supplied by intercostal, internal thoracic and musculophrenic arteries.
    - The veins drain mostly into the azygos and internal thoracic veins.
  - **The Visceral Pleura**
    - Is supplied by the bronchial arteries.
    - The veins drain into bronchial veins.
- **Lymphatic Drainage**
  - **The Parietal Pleura**
    - The lymphatics drain into the intercostal, internal mammary, posterior mediastinal and diaphragmatic nodes.
  - **The Visceral Pleura**
    - The lymphatics are drained by the bronchopulmonary lymph nodes.

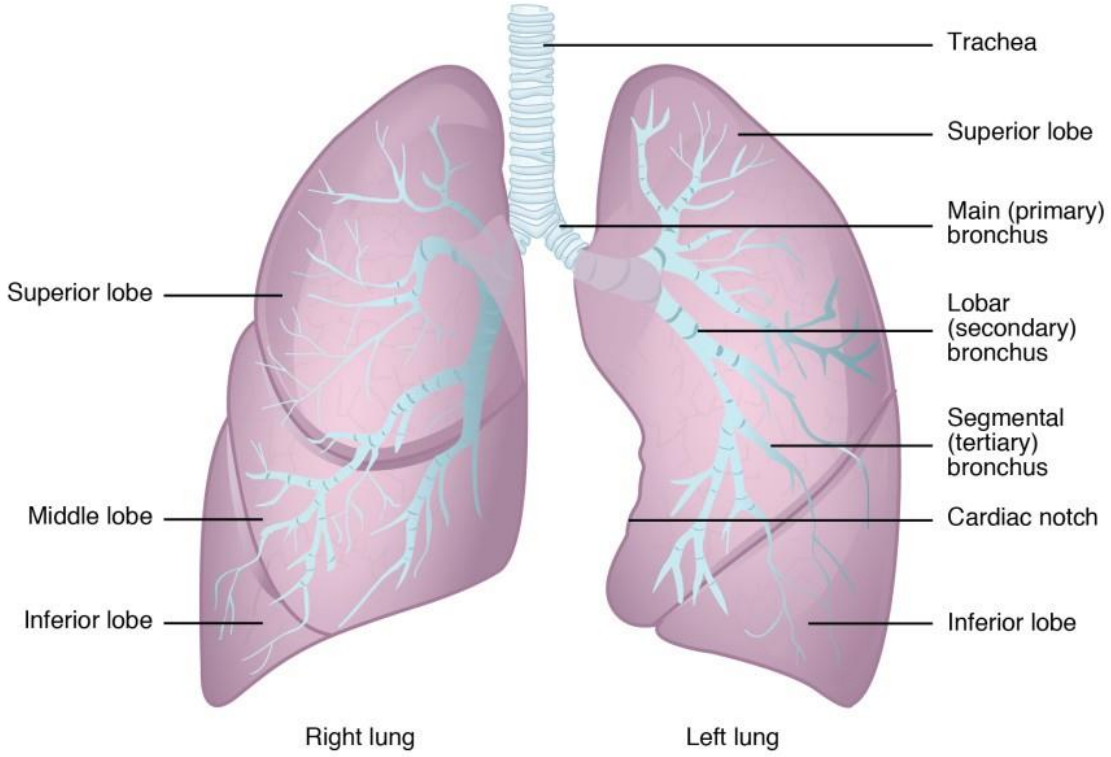
	Parietal Pleura	Visceral Pleura
Development	From the somatopleuric layer of the lateral plate of mesoderm	From the splanchnopleuric layer of the lateral plate of mesoderm.
Nerve Supply	Somatic nerves, specifically the intercostal and phrenic nerves.	Autonomic nerves. Sympathetic nerves derived from the 2nd to 5th sympathetic ganglia. Parasympathetic supply is from the Vagus nerve.
Note: the costal and peripheral parts of the diaphragmatic pleurae is supplied by the intercostal nerves while the mediastinal pleura and central part of the diaphragmatic pleurae is supply by the phrenic nerves.		
Sensitivity to Pain	Present	Absent



(c) Transverse section through the thorax, viewed from above. Lungs, pleural membranes, and major organs in the mediastinum are shown.

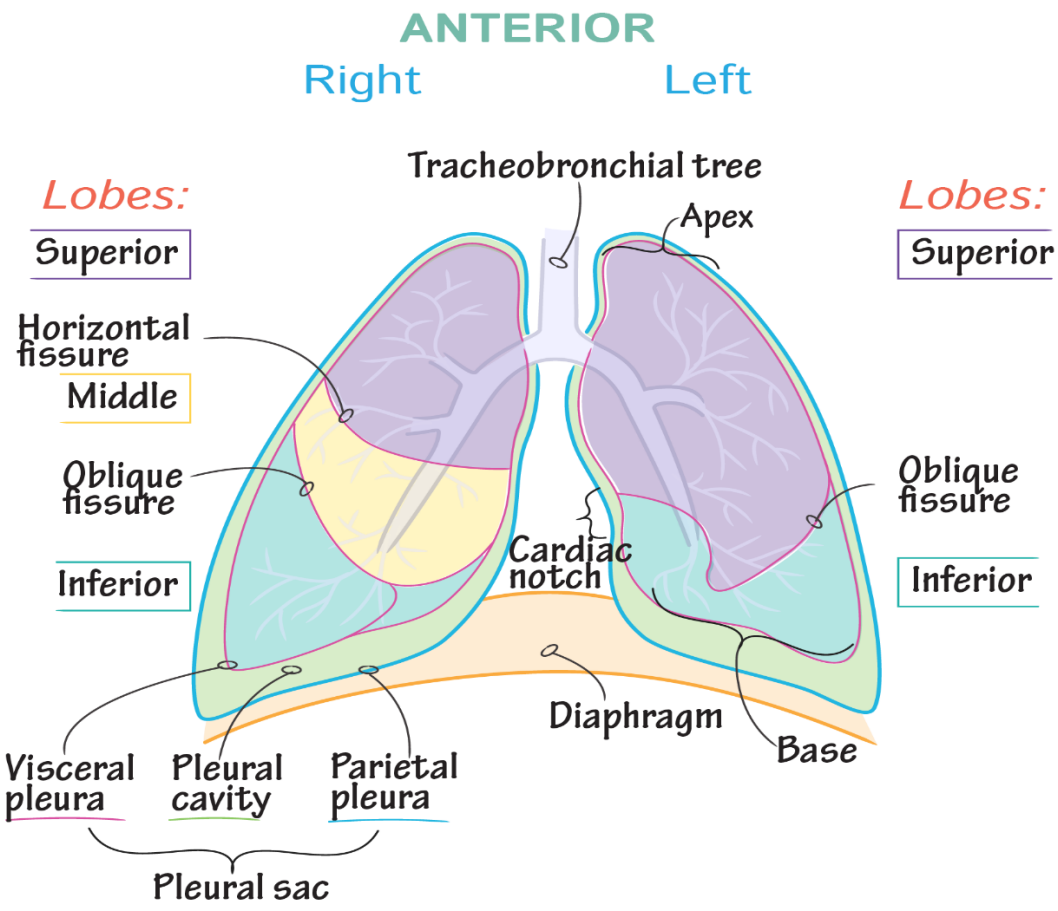
- **Additional Note:**
  - **The Pleura lies beyond the thoracic cage at 5 places:**
    - Right and left cervical pleura
    - Right and left costovertebral angles
    - Right xiphicostal angle
- **Clinical Anatomy:**
  - **Pleurisy**—inflammation of the pleura.
  - **Pneumothorax**—presence of air in the pleural cavity.
  - **Haemothorax**—presence of blood in the pleural cavity.
  - **Hydropneumothorax**—presence of both fluid and air in the pleural cavity.
  - **Empyema**—presence of pus in the pleural cavity.
  - **Pleural Effusion**—presence of fluid in pleural cavity due to different infections such as pulmonary Tuberculosis (T.B.)

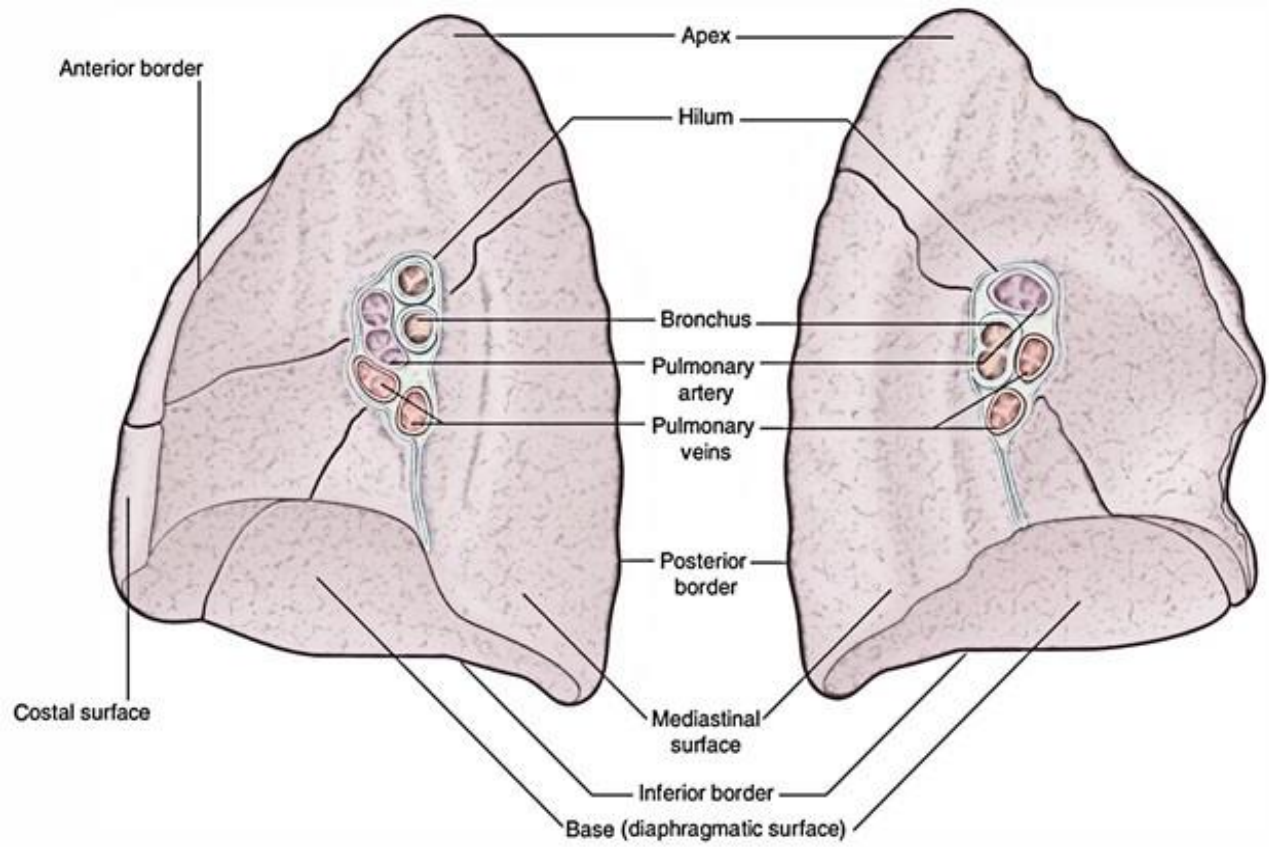
The Lungs



- **Definition:** the lungs are organs of respiration found in the thoracic cavity
- **Location:** they are located on either side of the mediastinum surrounded by the right and left pleural cavities.
    - The right lung is usually larger than the left lung due to the presence of the heart in the left side of the chest cavity.
- **Shape:** half-cone
    - It has a base, apex, two surfaces and three borders.
- **Texture:** Spongy
- **Color:** in the young the lungs are brown or grey in color, but over time it changes black due to the deposition of inhaled carbon particles.
- **Weight:**
    - Right Lung—about 700 grams.
    - Left Lung—about 600-650 grams.

- **Boundaries:**
  - **Apex**— it's blunt, it comes out from above the first rib and into the root of the neck.
  - **Base**— its shape is semilunar and concave. It sits on the diaphragm.
    - **It separates:**
      - The right lung from the right lobe of the liver
      - The left lung from the left lobe of the liver
      - The fundus of the stomach and the spleen.
  - **Surfaces:**
    - **Costal Surface**—it is large and convex. Found adjacent to the ribs and intercostal spaces of the thoracic wall.
    - **Mediastinal Surface**—lies against the mediastinum anteriorly and the vertebral column posterior. It contains the comma-shaped hilum of the lung through which structures enter and leave.





- **Borders:**
  - **Inferior border**—sharp and it is essential in separating the base from the costal surface and medial surfaces.
  - **Anterior border**—it is sharp, thin, and shorter than the posterior border. It separates the costal surface from the medial surface.
    - Anterior border of the left lung shows a wide cardiac notch below the level of the 4th costal cartilage.
    - Below the cardiac notch there is a tongue shaped projection of the left lung called the *lingula.*
  - **Posterior border**—it is thick, smooth and rounded, it also separates the costal surface from the medial surface. Related to the heads of the ribs.
    - **Extension:** from the 7th cervical spine to the 10th thoracic spine.

- **Lobes of the Lungs**
  - **Right Lung:**
    - is divided into 3 lobes by two fissures (oblique and horizontal fissure)
- **Note:** the oblique fissure cuts into the whole thickness of the lung, except at the hilum.
  - **Left Lung:**
    - Is divided into 2 lobes by the oblique fissure.
    - The *lingula* is a tongue-shaped projection of the left lung found below the cardiac notch.

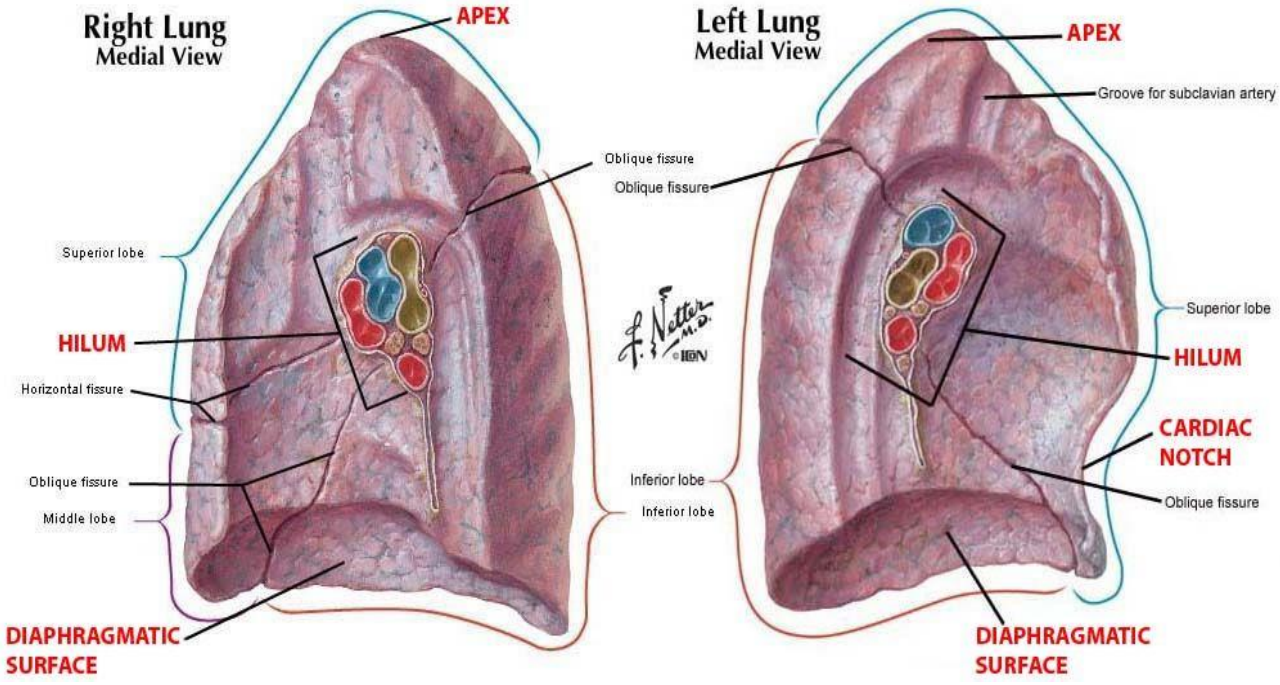
Table 16.2: Differences between the right and left lungs

Right lung	*Left lung*
1. It has 2 fissures and 3 lobes	1. It has only one fissure and 2 lobes
2. Anterior border is straight	2. Anterior border is interrupted by the cardiac notch
3. Larger and heavier, weighs about 700 g	3. Smaller and lighter, weighs about 600 g
4. Shorter and broader	4. Longer and narrower

Root of the Lung

- **Definition:** is a short broad pedicle which connects the medial surface of the lung to the mediastinum.
    - It's made up of a collection of structures which either enter or come out of the lung at the hilum.
- **Arrangement of the Structures in the Root:**
    - **From anterior to posterior**
        - Superior Pulmonary Vein
        - Pulmonary Artery
        - Bronchus
    - **From above downwards**

Difference between Right and Left Root of the Lung	
Right Side	**Left Side**
Eparterial Bronchus	Pulmonary Artery
Pulmonary Artery	Bronchus
Hyparterial Bronchus	Inferior Pulmonary Vein
Inferior Pulmonary Vein	



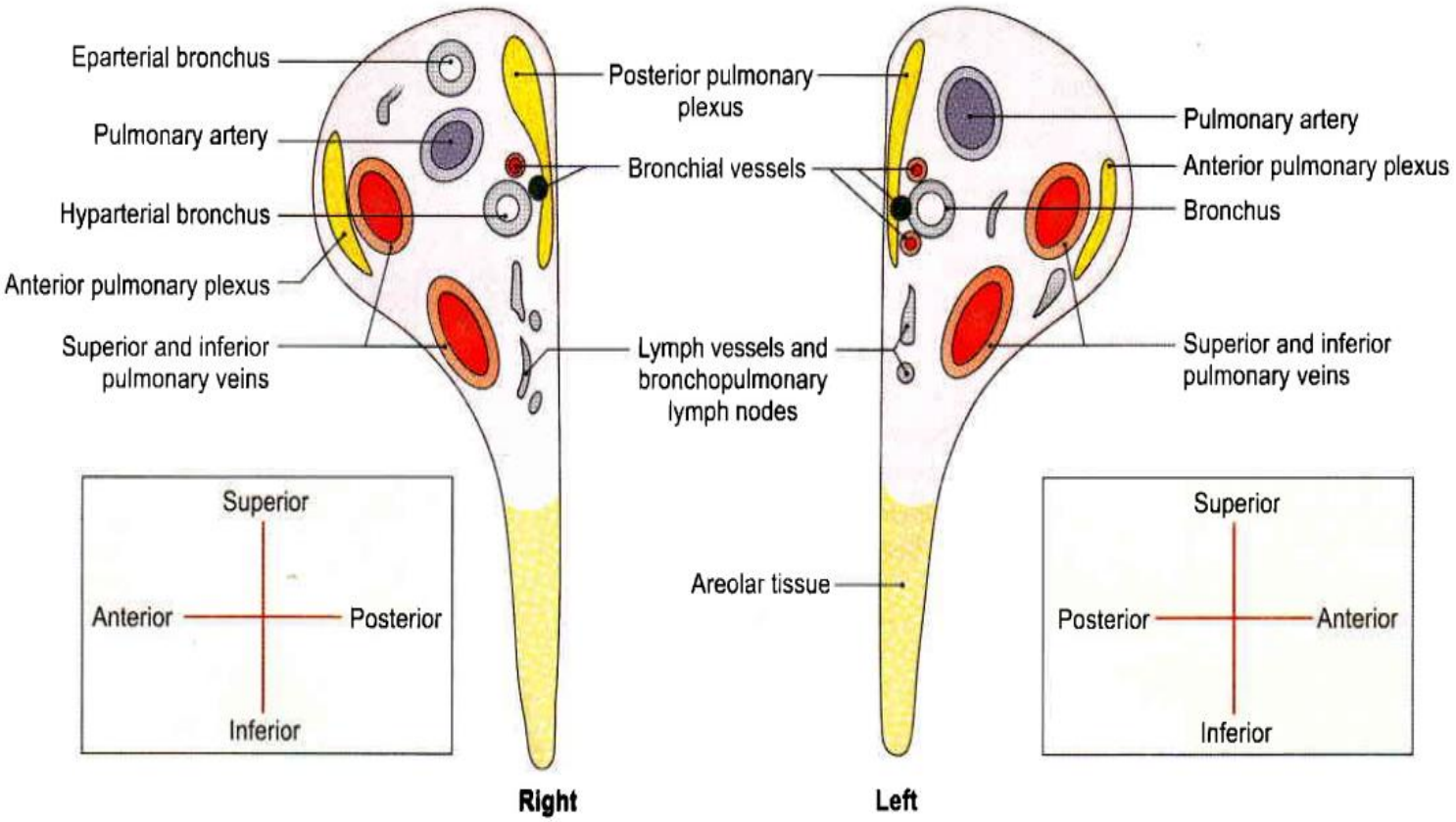
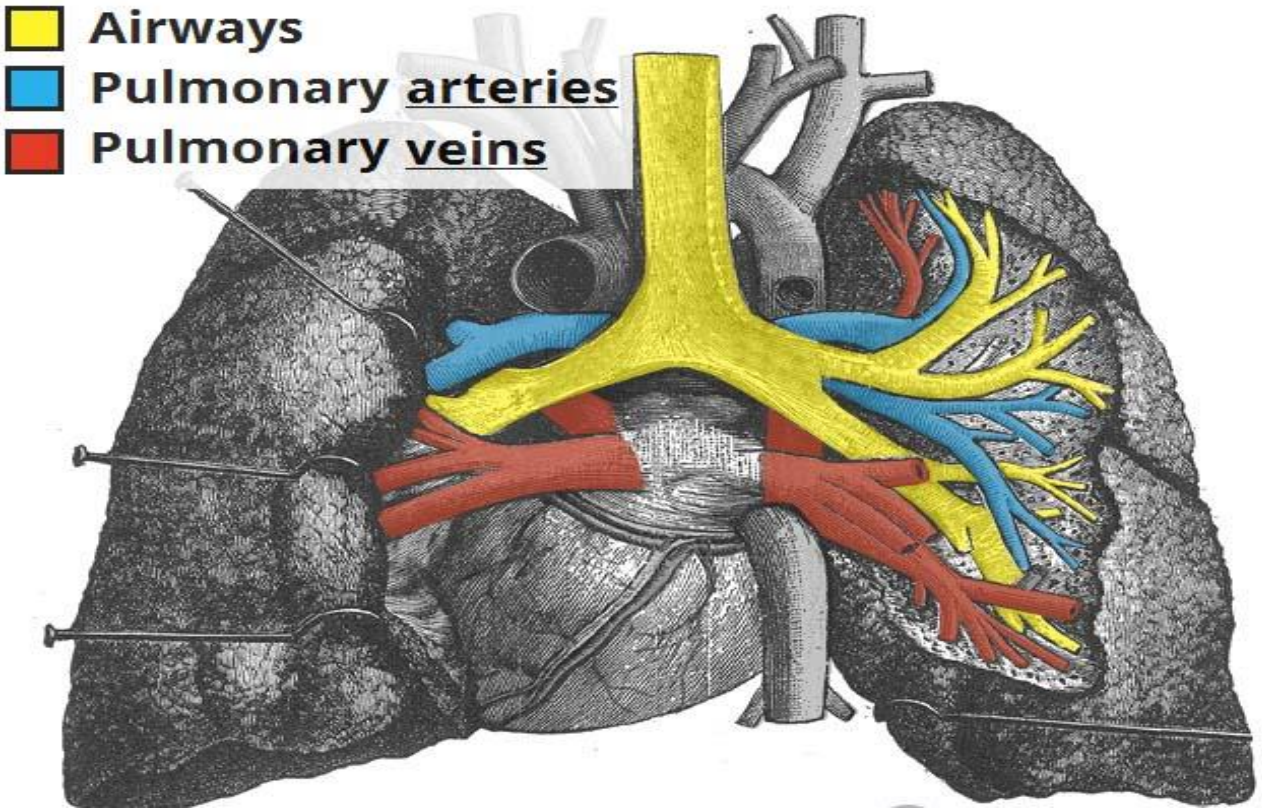


Fig. 16.4: Roots of the right and left lungs seen in section

- **Blood Supply of the Lungs:**
  - **Right Side:**
    - One bronchial artery which arises from the 3rd right posterior intercostal artery.
  - **Left Side:**
    - Two bronchial arteries both of which arise from the descending thoracic aorta.

Note: Deoxygenated blood is brought to the lungs by the two pulmonary arteries and oxygenated blood is returned to the heart by the four pulmonary veins.

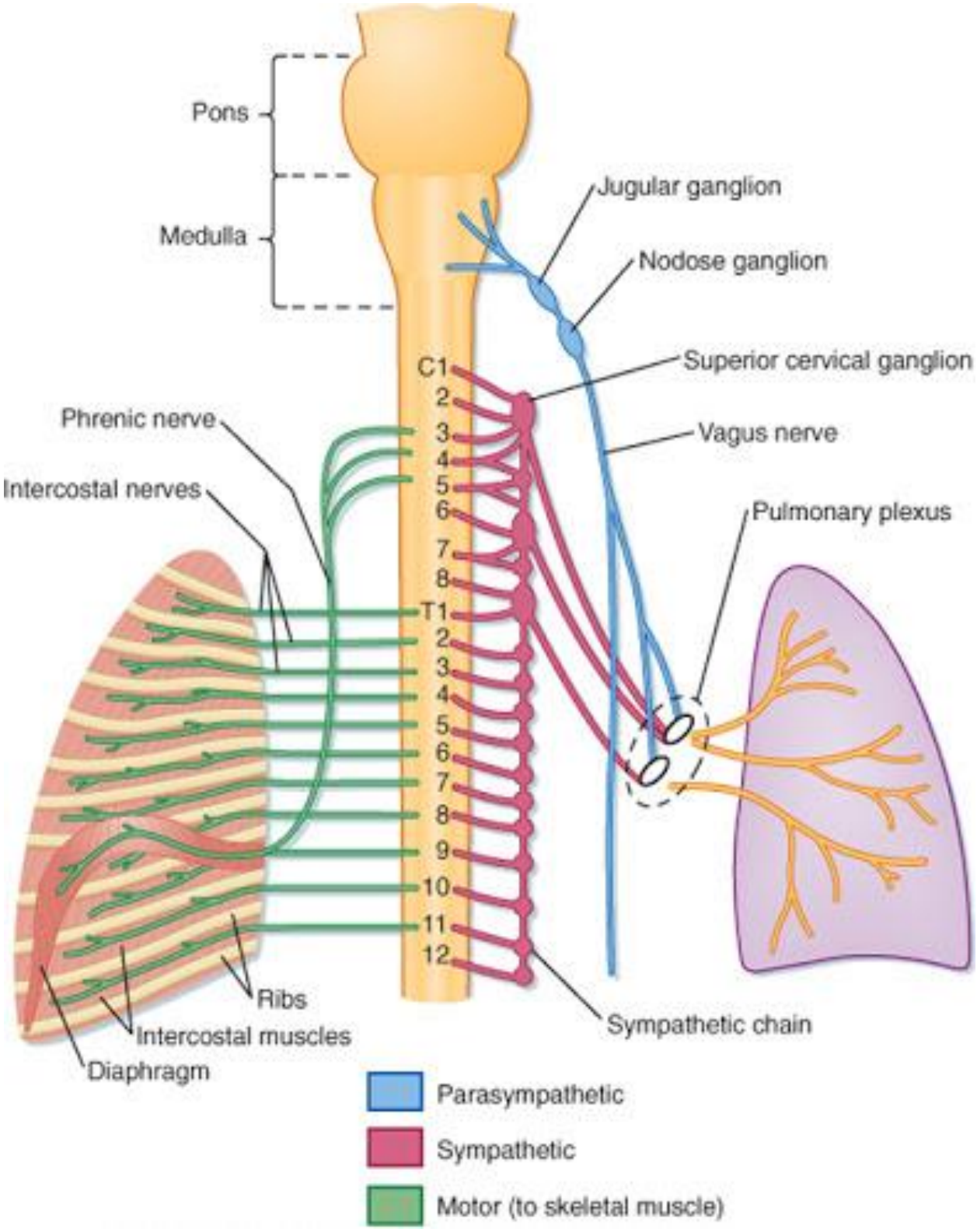
- **Venous Drainage of the Lungs:**
  - There are usually two bronchial veins on each side.
    - Right Bronchial veins drain into the Azygos Vein
    - Left Bronchial veins drain into the Hemiazygos Vein
    - The greater part of the venous blood from the lungs is drained by the pulmonary veins.



- **Lymphatic Drainage:**
    - There are two sets of lymphatics, but they eventually end up in the Bronchopulmonary Nodes.
        - Superficial vessels drain the peripheral lung tissue that lies under the pulmonary pleura.
        - Deep Lymphatics drain the bronchial tree, the pulmonary vessels and the connective tissue septa.
    - The Superficial and Deep lymphatics eventually run towards the hilum draining into the bronchopulmonary nodes.

Note: The superficial vessels have numerous valves and the deep vessels have only a few valves or no valves at all.

- **Nerve Supply:**
    - Parasympathetic nerves are derived from the Vagus nerve.
        - Motor—to the bronchial muscles, on stimulation causes bronchospasm
        - Secretomotor—to the mucous glands of the bronchial tree
        - Secretory fibers—responsible for the stretch reflex of the lungs.
    - Sympathetic nerves are derived from the 2^{nd} to 5^{th} sympathetic ganglia.
        - Inhibitory to the smooth muscles and glands of the bronchial tree.

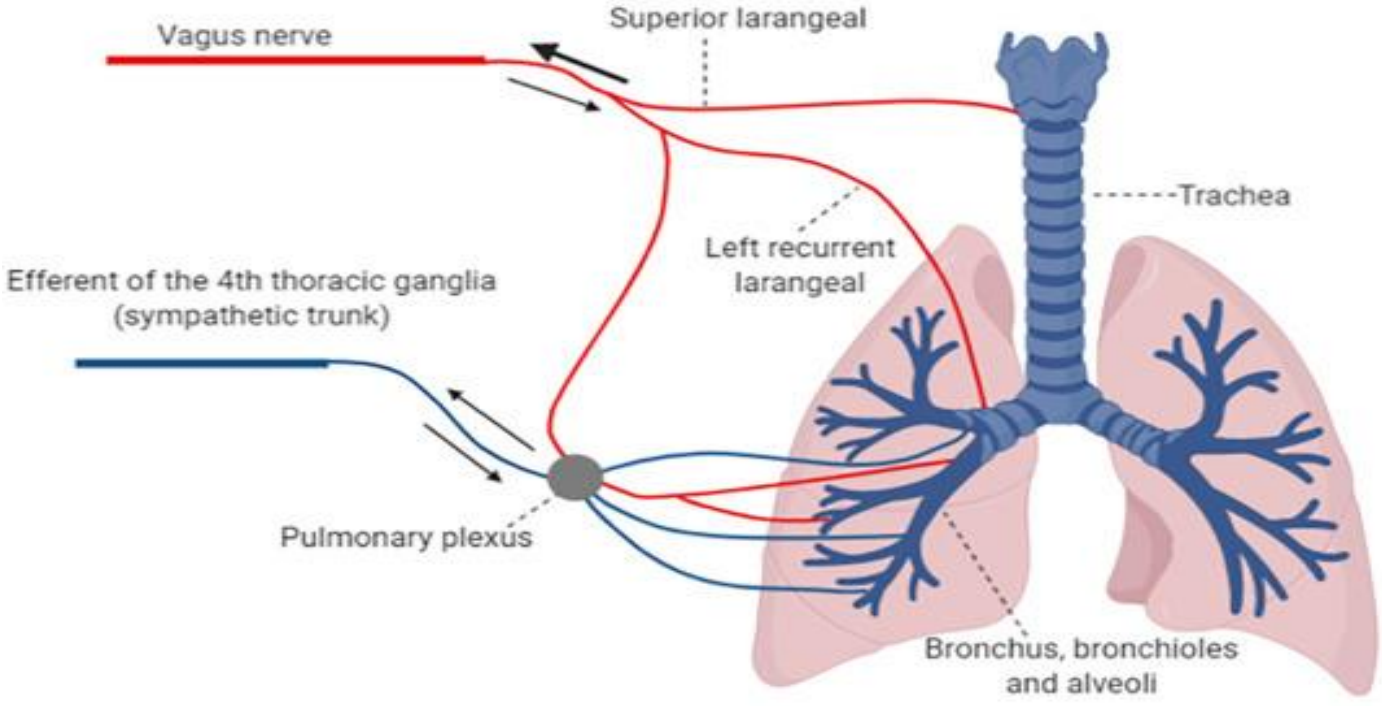

Pons
Medulla
Jugular ganglion
Nodose ganglion
Superior cervical ganglion
Vagus nerve
Pulmonary plexus
Phrenic nerve
Intercostal nerves
C1
2
3
4
5
6
7
8
T1
2
3
4
5
6
7
8
9
10
11
12
Ribs
Intercostal muscles
Diaphragm
Sympathetic chain
Parasympathetic
Sympathetic
Motor (to skeletal muscle)

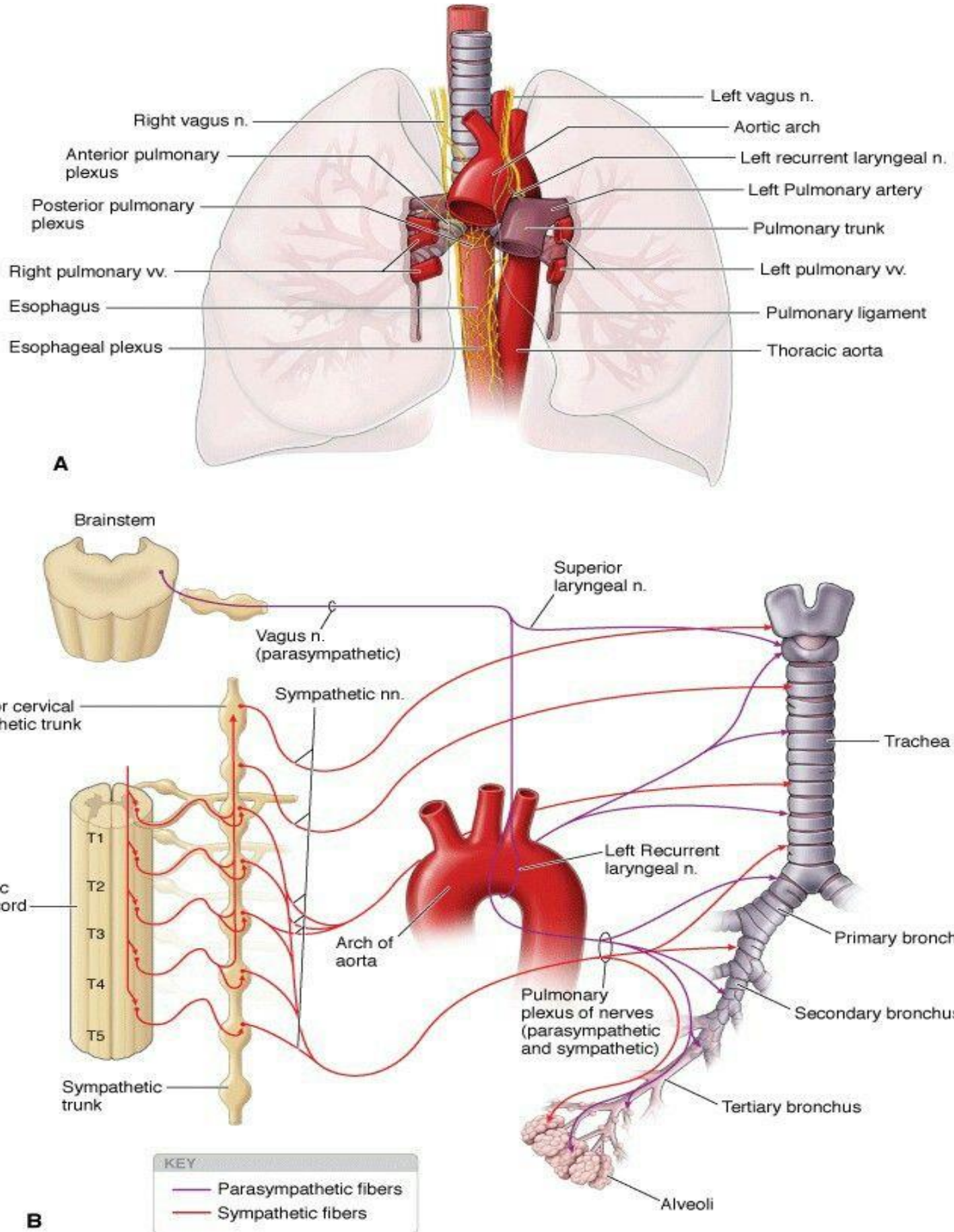
Pulmonary Plexuses

	Posterior Pulmonary Plexus	Anterior Pulmonary Plexus
Site:	Lies behind the roots of the lungs.	Lies infront of the roots of the lung.
Formation:	**Formed behind the bronchus by:** • Parasympathetic fibers from the vagus nerve. • Sympathetic fibers from the 2nd, 3rd, and 4th thoracic sympathetic ganglia.	**Formed infront of the bronchus by:** • Filaments from the posterior pulmonary plexus • Filaments from the deep cardiac plexus
Functions:	• **Parasympathetic fibers—**are bronchoconstrictors, secretomotor to bronchial glands, and vasodilate. ○ Concerned With the respiratory reflexes • **Sympathetic fibers**—are bronchodilator, vasoconstrictor, and sensory to the bronchial tree and visceral pleura.	

Note:

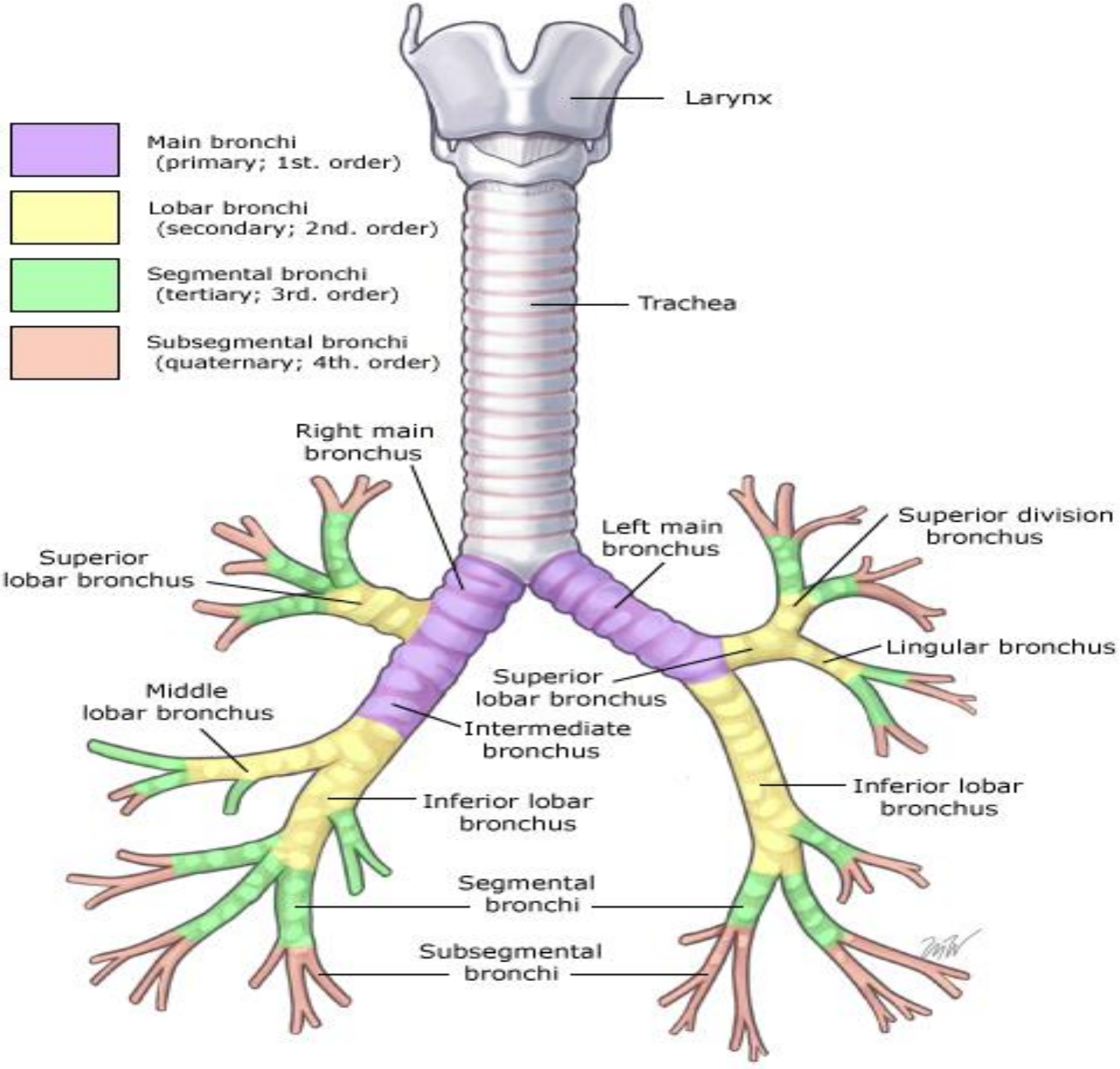
- **The posterior pulmonary plexus is larger than the anterior pulmonary plexus.**
- **The anterior pulmonary plexus also receives fibers from the superficial cardiac plexus.**



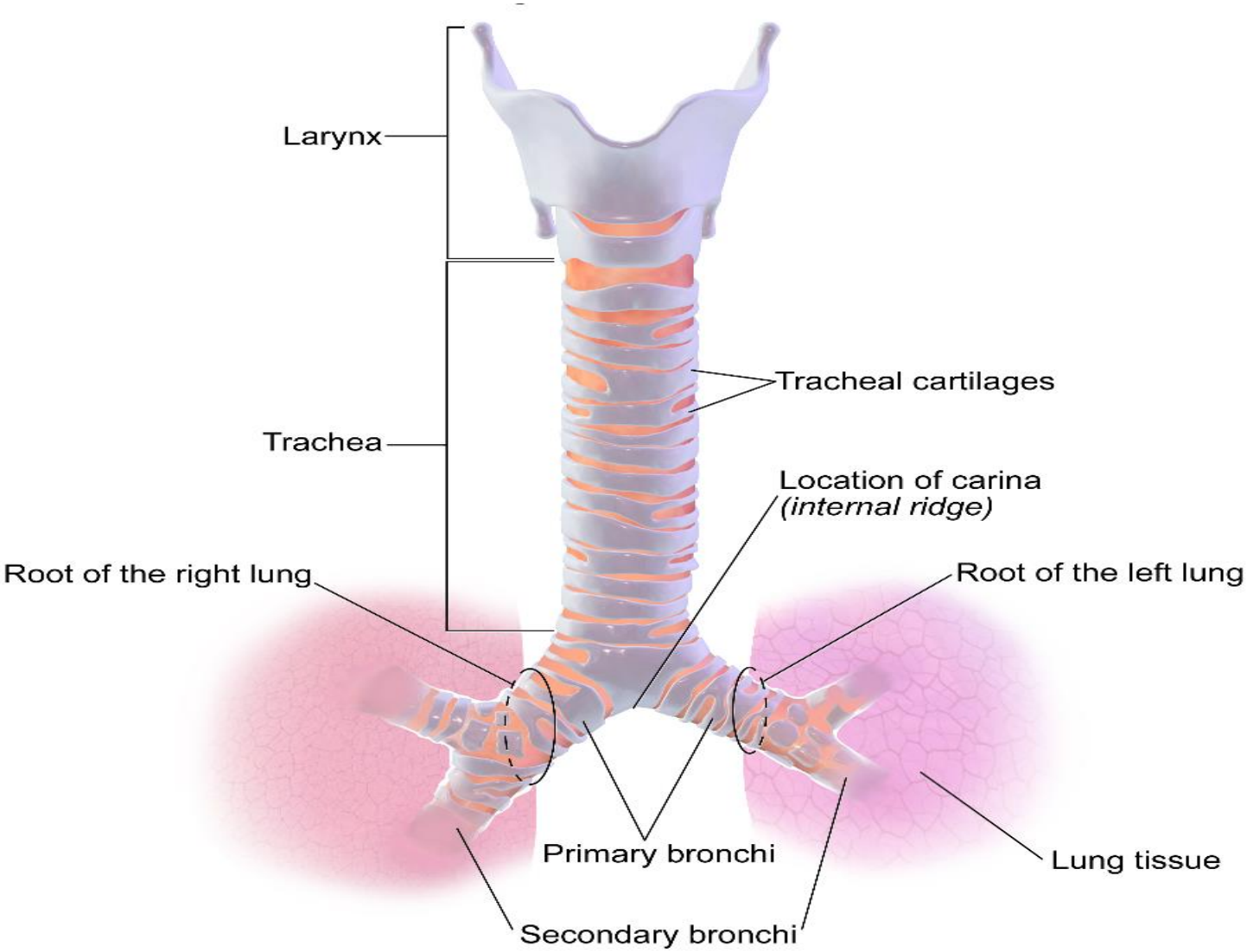

Left vagus n.
Right vagus n.
Aortic arch
Anterior pulmonary plexus
Left recurrent laryngeal n.
Left Pulmonary artery
Posterior pulmonary plexus
Pulmonary trunk
Right pulmonary vv.
Left pulmonary vv.
Esophagus
Pulmonary ligament
Esophageal plexus
Thoracic aorta
A
Brainstem
Superior laryngeal n.
Vagus n. (parasympathetic)
Sympathetic nn.
Superior cervical sympathetic trunk
Trachea
T1
T2
T3
T4
T5
Thoracic spinal cord
Left Recurrent laryngeal n.
Primary bronchus
Arch of aorta
Pulmonary plexus of nerves (parasympathetic and sympathetic)
Secondary bronchus
Sympathetic trunk
Tertiary bronchus
KEY
Parasympathetic fibers
Sympathetic fibers
Alveoli
B

The Tracheobronchial Tree

- **Definition:** the tracheobronchial tree is formed by the trachea, bronchi and bronchioles.
- **Function:** together they are a system of airways that allow the passage of air into the lungs and where gas exchange occurs.



Trachea



- **Definition:** the trachea (Latin for air vessels) or the windpipe is the tube for passage of air to and from the lungs.
- **Location:** the trachea lies in the midline or in the lower part of the neck and in the superior mediastinum.
- **Length:** 10-15 cm.
- **External Diameter:** 2 cm in males, and 1.5 cm in females.

- **Lumen:** is 3mm to 12mm, it usually increases 1mm per year until the age of 12 when it stops increasing.
    - It is lined by ciliated columnar epithelium and contains many mucous and serous glands.
- **Begins:** it arises at the lower border of cricoid cartilage in the neck, as a continuation of the larynx. It continues in the midline but just before bifurcating it inclines more towards the right side.
- **Ends:** The trachea divides at the level of the lower border of the 4th thoracic vertebra.
- **Structure:** the trachea has a fibroelastic wall supported by a cartilaginous skeleton formed by C-shaped rings
    - There are about 16-20 in number, the ends of these rings are supported by trachealis muscle.

Relations of the Trachea at the thoracic part			
Anteriorly	**Posteriorly**	**On the Right Side**	**On the Left Side**
• Manubrium • Sternothyroid Muscles • Remains of the thymus • Left brachiocephalic • Inferior Thyroid veins • Aortic Arch • Brachiocephalic Artery • Left Common Carotid Artery • Deep Cardiac Plexus • Some lymph nodes	• Esophagus • Vertebral Column	• Right Lung and pleura • Right Vagus • Azygos Vein	• Arch of Aorta • Left Common Carotid Artery • Left Subclavian Artery • Left Recurrent Laryngeal nerve.

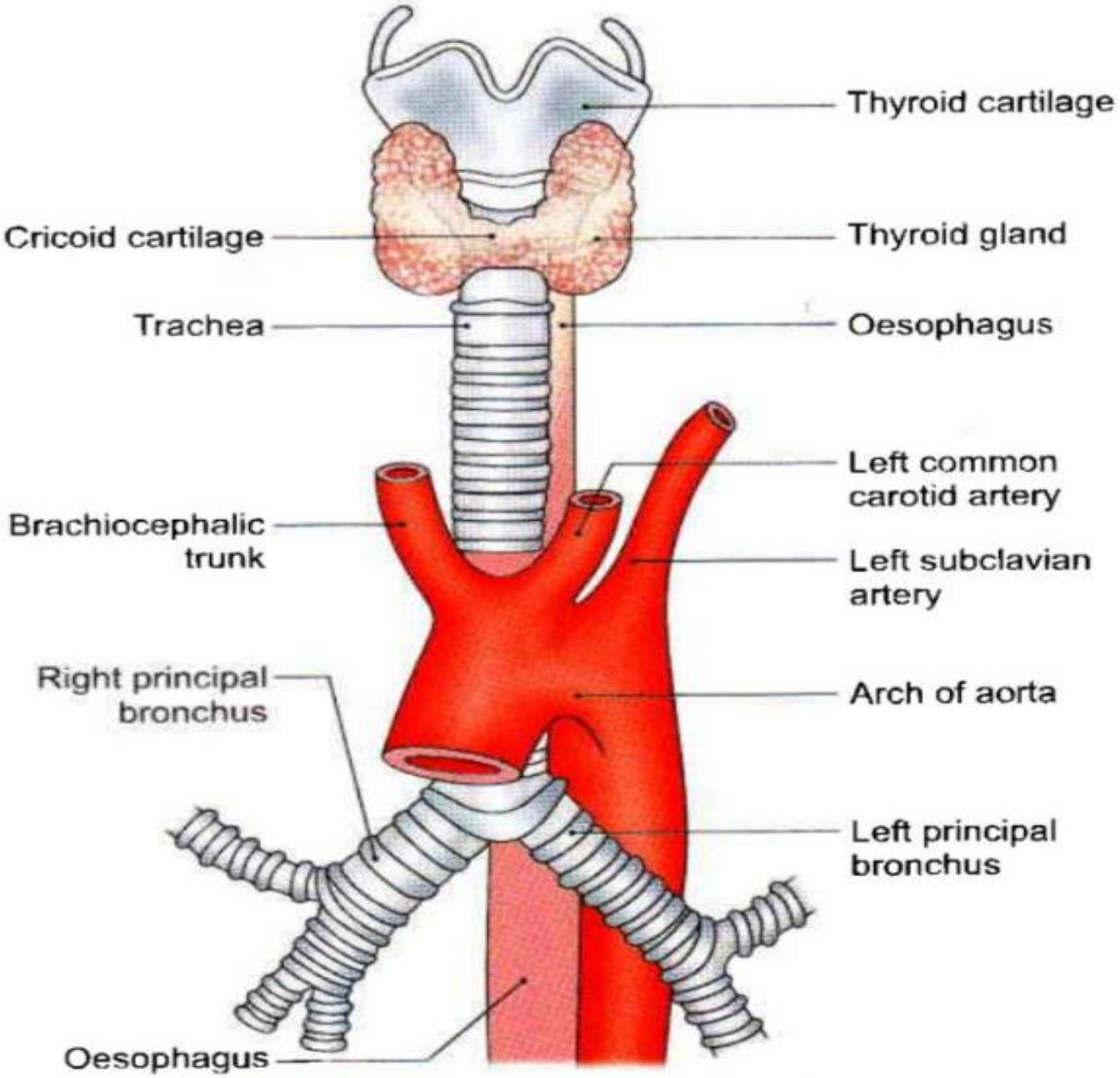
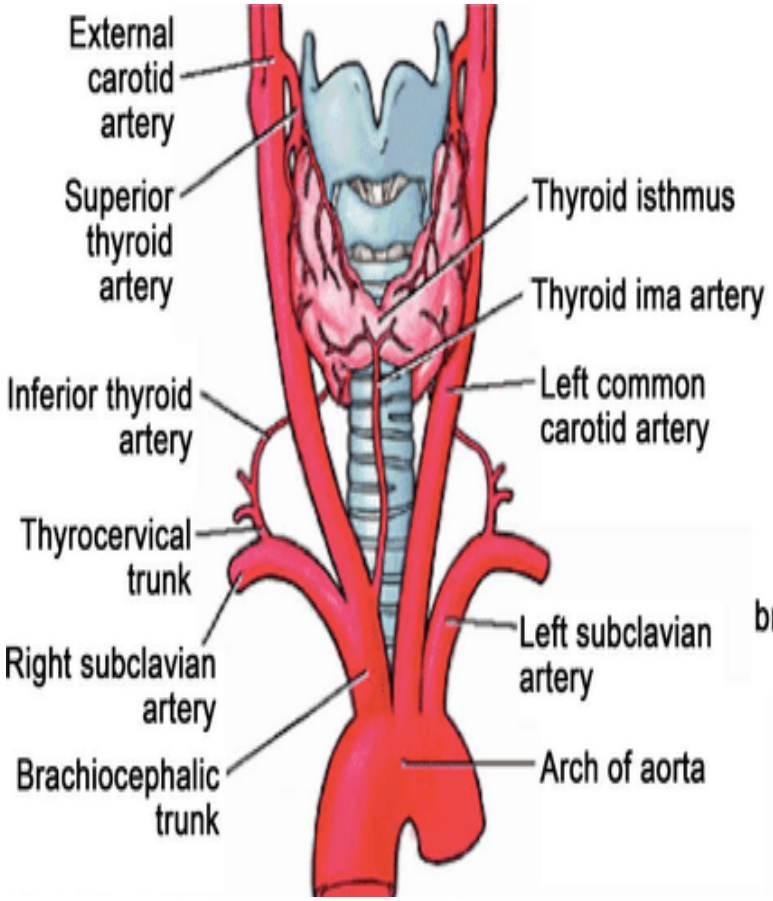
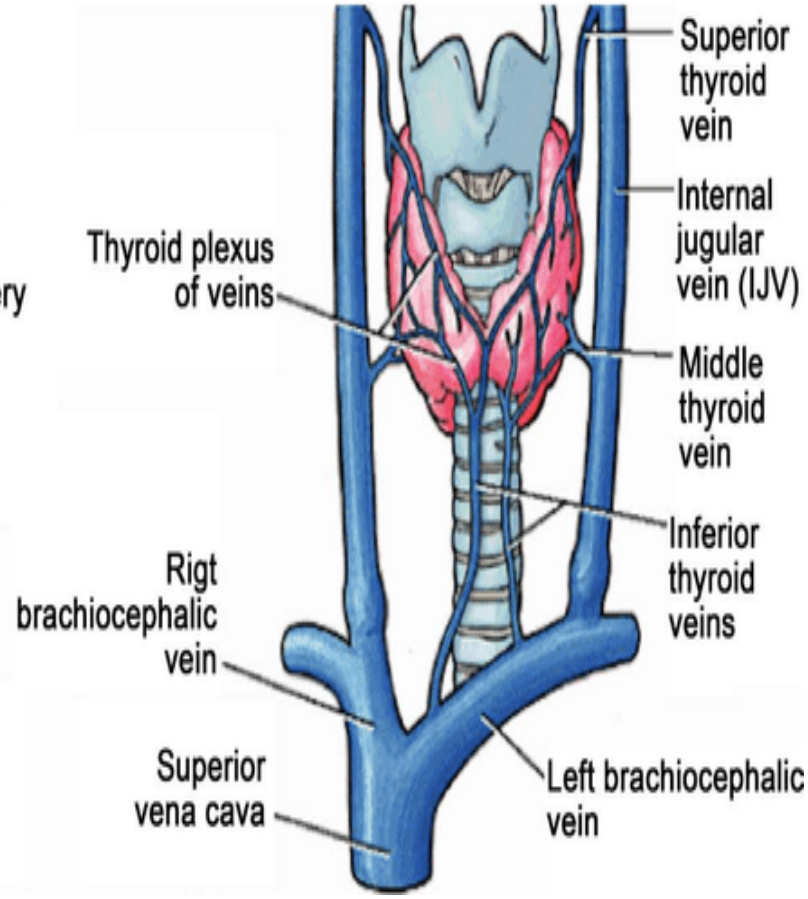


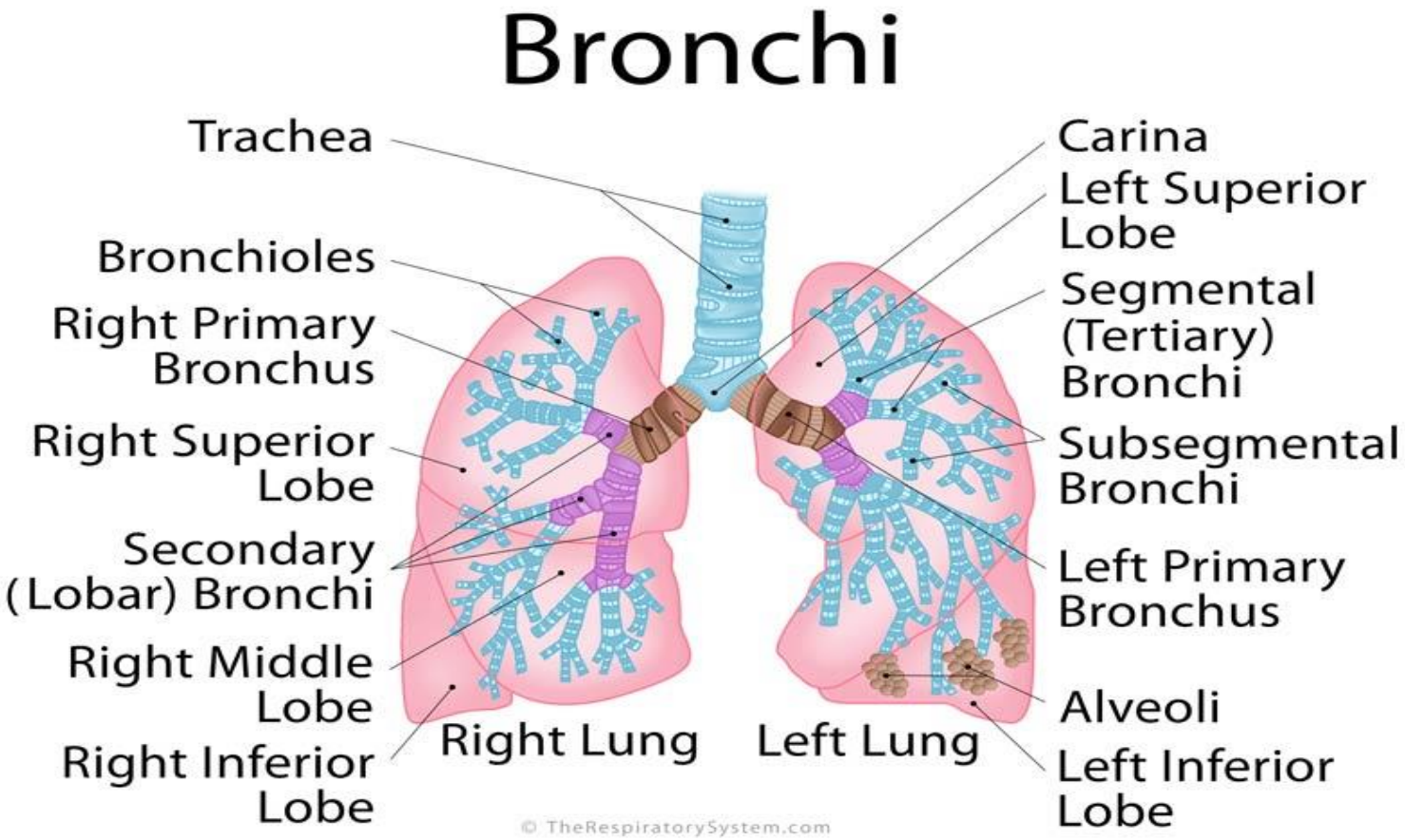
Fig. 20.1: Trachea and its relations

- **Blood Supply:**
    - Tracheal branches of the inferior thyroid arteries
- **Venous Drainage:**
    - Into the left brachiocephalic, azygos and accessory hemiazygos veins.
- **Lymphatic Drainage:**
    - To the peritracheal and paratracheal nodes
- **Nerve Supply:**
    - Vagi and recurrent laryngeal nerves.





Bronchi

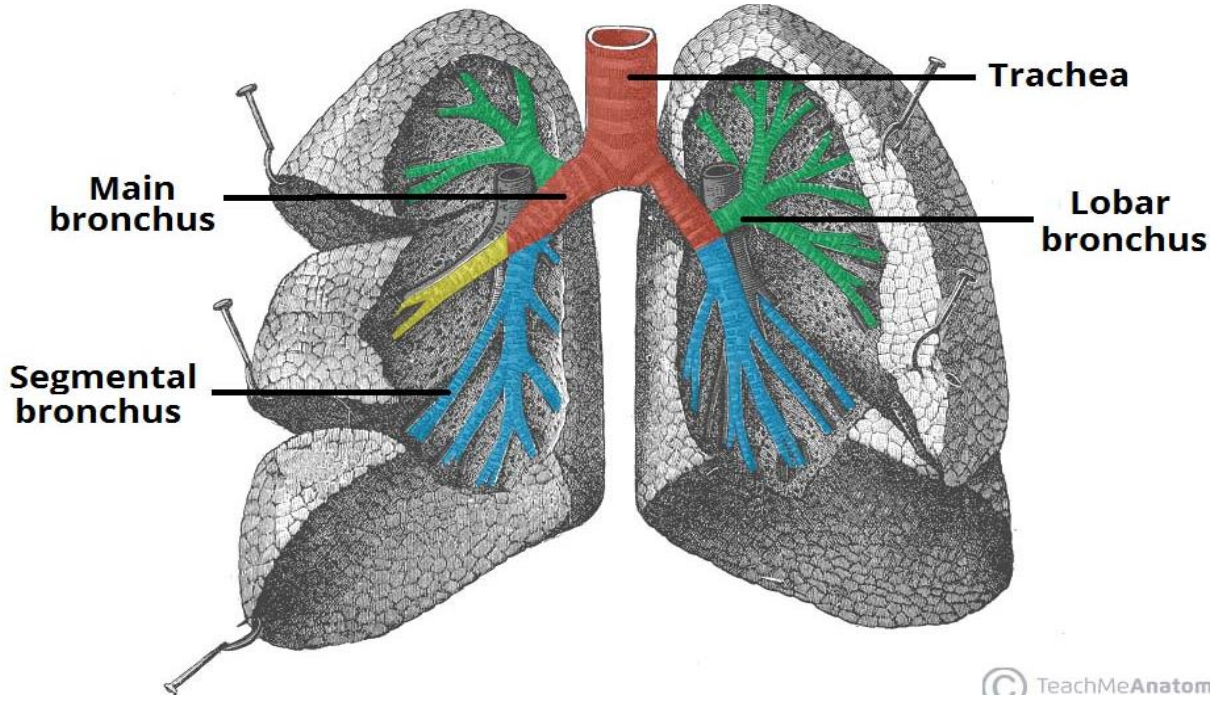


- **Definition:** when the trachea divides at the level of the lower border of the 4th thoracic vertebra it forms the primary principle bronchi, one for each lung.

- **Right Principle Bronchus:**
  - **Size:** 2.5 cm long
  - It's shorter, wider and more in line with the trachea than the left principal bronchus.
    - **Note:** infections are more common on the right side because it's more in line with the trachea.
- **Left Principal Bronchus:**
  - **Size**: 5cm long
  - It's longer, narrower and more oblique than the right bronchus.

The differences between the two bronchi

The right bronchus	The left bronchus
2.5 centimeters (one inch) long	5 centimeters (two inches) long
Shorter	Longer & narrower
It enters the lung opposite T5	It enters the lung opposite T6
More in line with trachea	Less in line with trachea
Gives 3 lobar bronchi, on entering the hilum, it divides into a middle and an inferior lobar bronchus.	Gives 2 lobar bronchi, on entering the hilum of the left lung, the principal bronchus divides into a superior and an inferior lobar bronchus.
The right pulmonary artery crosses in front of the stem of the right bronchus below the origin of its 1st branch.	The left pulmonary artery crosses in front of the left bronchus before it gives its 1st branch.
The orifice of the right bronchus being larger	The orifice of the left bronchus being smaller
The azygos vein arches over it from behind	The arch of aorta crosses above the left bronchus from in front backwards
Foreign bodies usually enter the right bronchus placed nearly in line with the trachea	foreign bodies usually enter the left bronchus less commonly



1. Each principle bronchus enters the lung through the hilum and divides into secondary lobar bronchi, one for each lobe of the lungs.
    - Therefore, there are 3 lobar bronchi on the right side and 2 lobar bronchi on the left side.
2. Each lobar bronchus divides into **tertiary or segmental bronchi**, one for each bronchopulmonary segment.
    - There are 10 segmental bronchi on each side.
3. Each segmental bronchi divides repeatedly to form small branches called bronchioles.
    - **Bronchioles**
        - **Definition:** they are the smallest airways that do not contain cartilage nor mucous secreting cells.
        - Instead, the bronchioles contain cells that produce a surfactant lipoprotein which is essential in preventing the walls of the small airways from sticking together during expiration.
4. The bronchioles further branch forming terminal bronchioles.
5. There are still smaller branches called respiratory bronchioles.
    - **Respiratory bronchioles** bring air into a small part of the lung known as a **pulmonary unit.**
    - The respiratory bronchioles are distinguished by the presence of alveoli extending from their lumens.
6. Each respiratory bronchiole ends in microscopic passages called:
    a. Alveolar Ducts
    b. Atria
    c. Air Saccules
    d. Pulmonary Alveoli

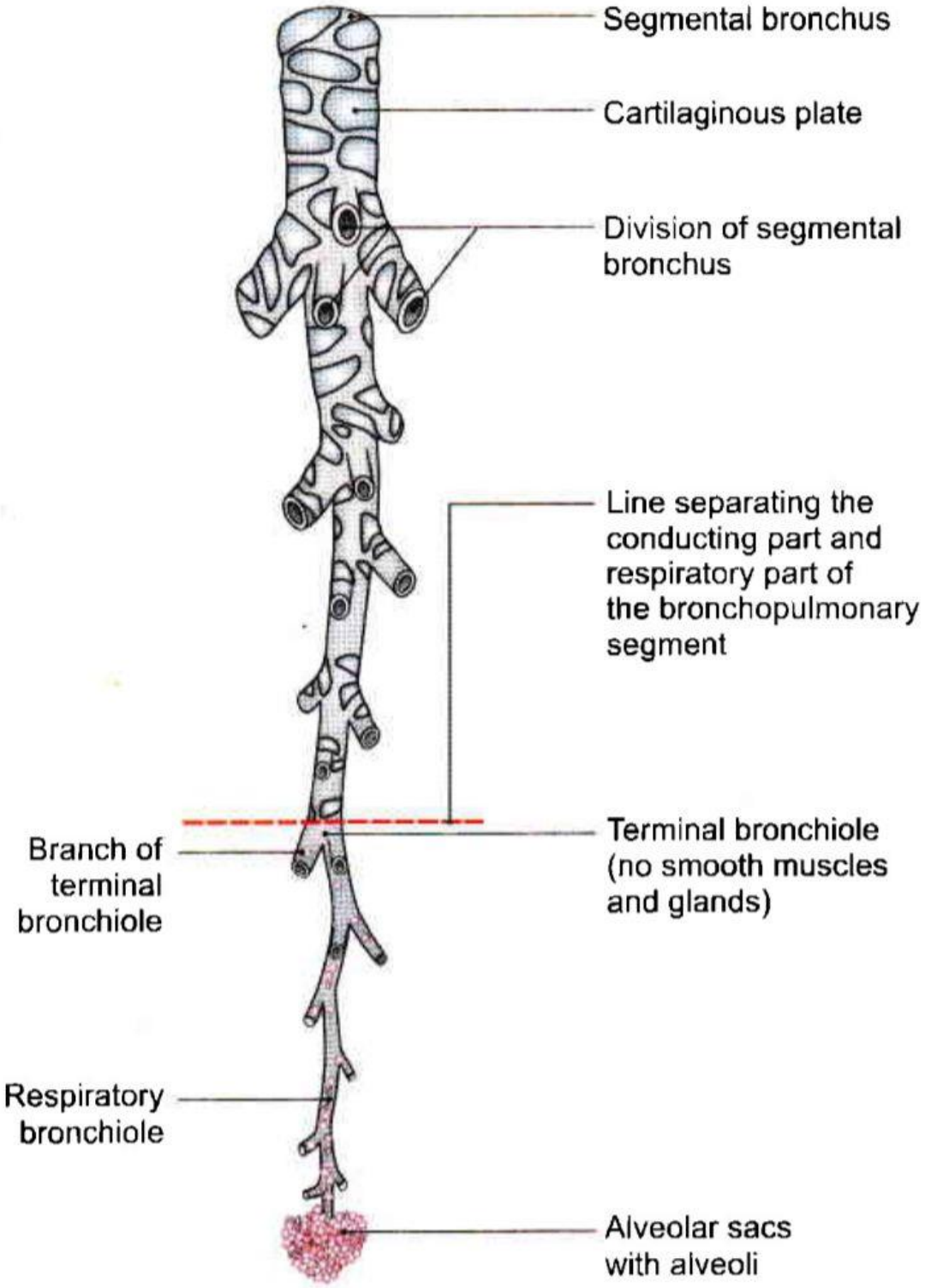
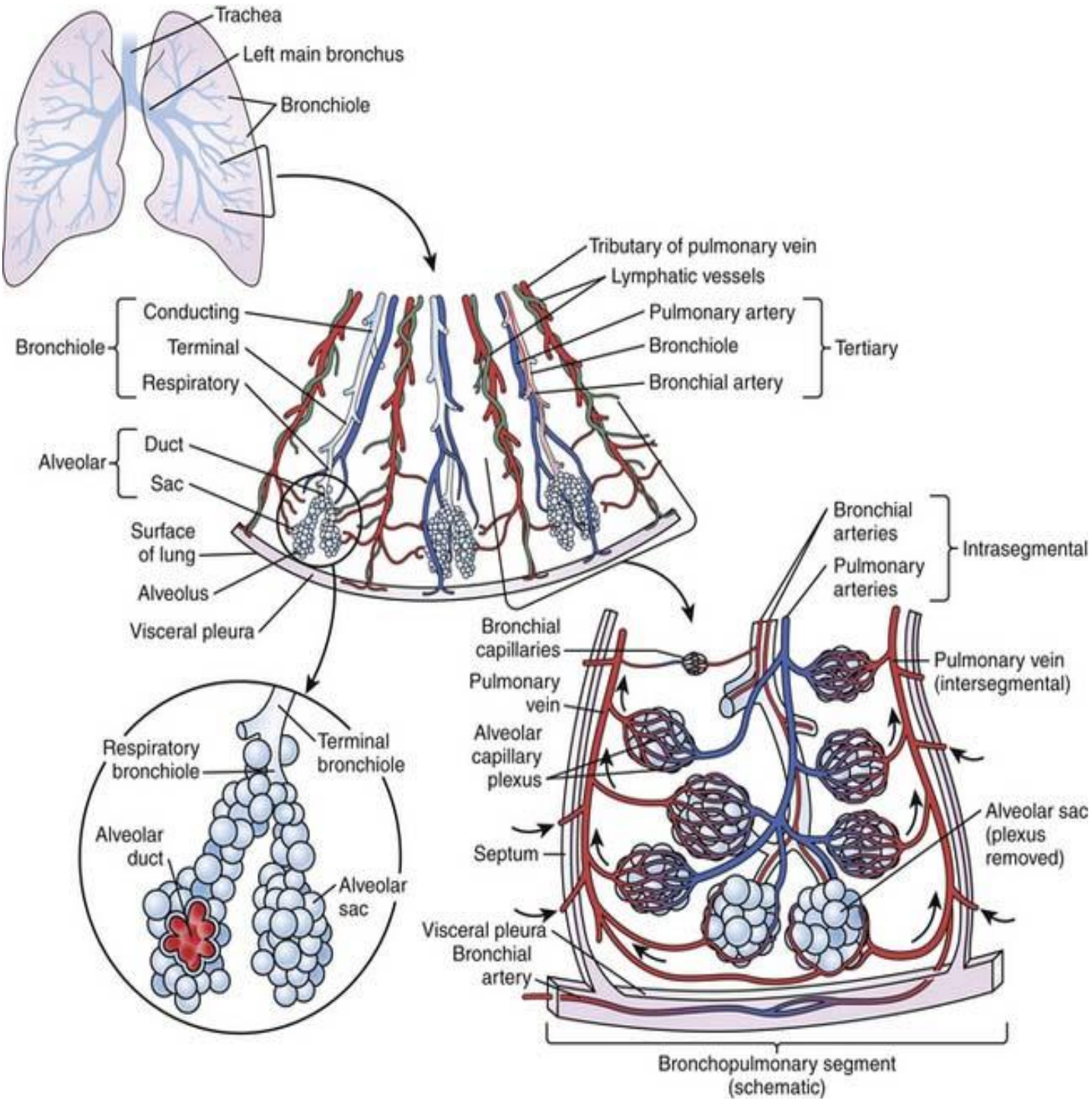

Segmental bronchus
Cartilaginous plate
Division of segmental bronchus
Line separating the conducting part and respiratory part of the bronchopulmonary segment
Terminal bronchiole (no smooth muscles and glands)
Branch of terminal bronchiole
Respiratory bronchiole
Alveolar sacs with alveoli

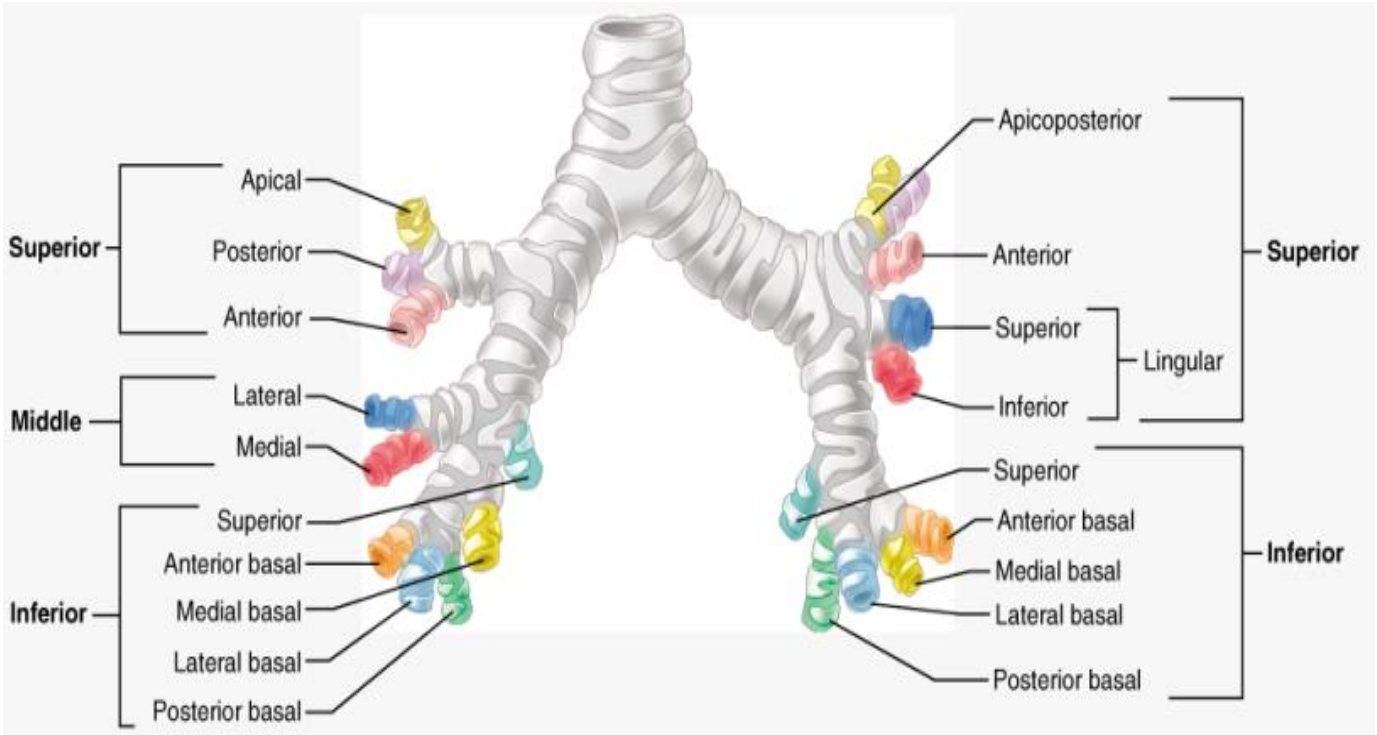
Fig. 16.6: Bronchial tree

Bronchopulmonary Segments

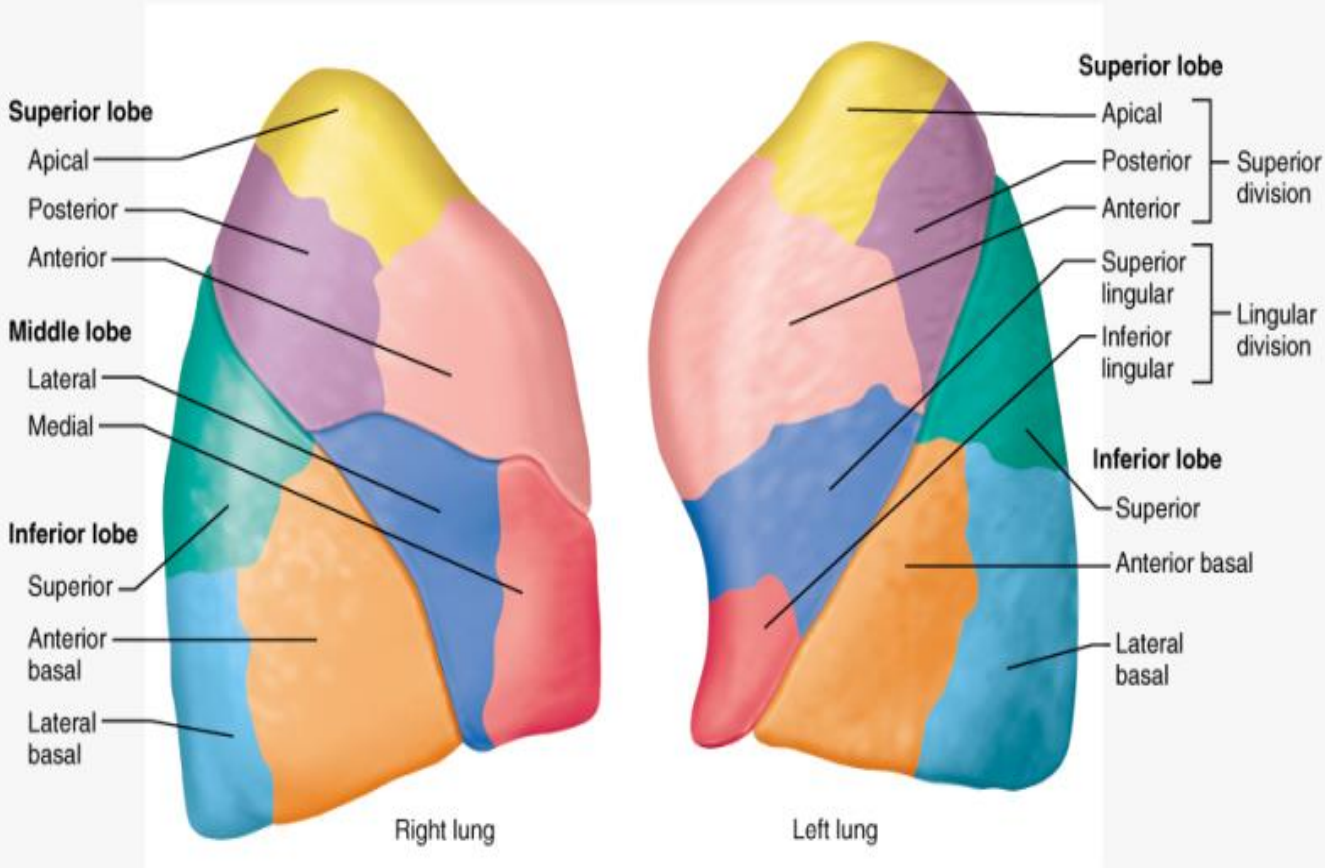
- **Definition:** bronchopulmonary segments are independent functional units of the lung.
- **Shape:** pyramidal

- **Structure:**
  - The Bronchi's structure is very similar to that of the trachea, though some differences are seen int eh shape of their cartilage.
    - In the main bronchi, cartilage rings completely encircle the lumen.
    - However, in the smaller lobar and segmental bronchi cartilage is found only in crescent shapes.
- **Blood Supply:**
  - Branches of the Bronchial Arteries
- **Venous Drainage:**
  - Into the Bronchial Veins.
- **Nerve Supply:**
  - Derived from the pulmonary branches of the vagus nerve.


Trachea
Left main bronchus
Bronchiole
Tributary of pulmonary vein
Lymphatic vessels
Bronchiole
Conducting
Terminal
Respiratory
Pulmonary artery
Bronchiole
Bronchial artery
Tertiary
Alveolar
Duct
Sac
Surface of lung
Alveolus
Visceral pleura
Bronchial arteries
Pulmonary arteries
Intrasegmental
Bronchial capillaries
Pulmonary vein
Alveolar capillary plexus
Septum
Visceral pleura
Bronchial artery
Pulmonary vein (intersegmental)
Alveolar sac (plexus removed)
Respiratory bronchiole
Terminal bronchiole
Alveolar duct
Alveolar sac
Bronchopulmonary segment (schematic)

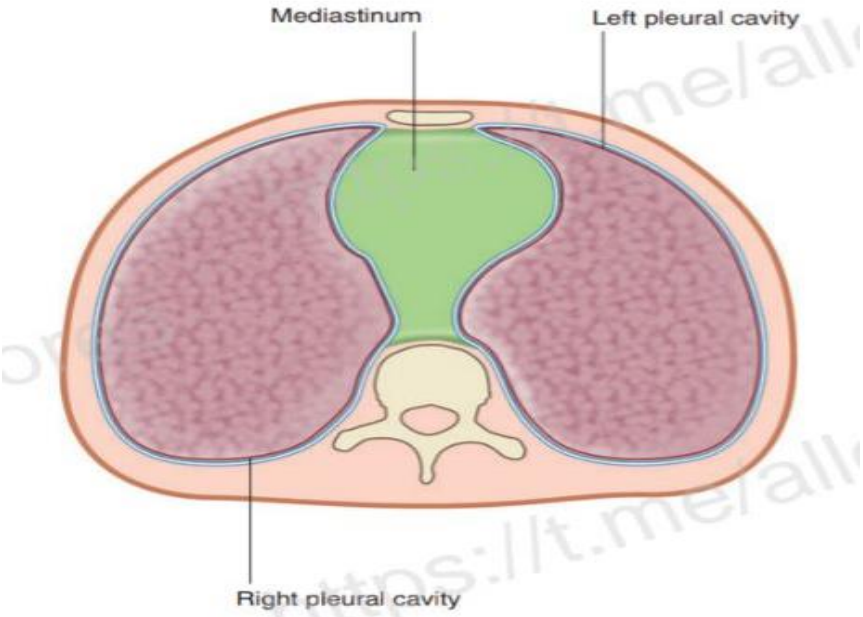


(a) Segmental bronchi



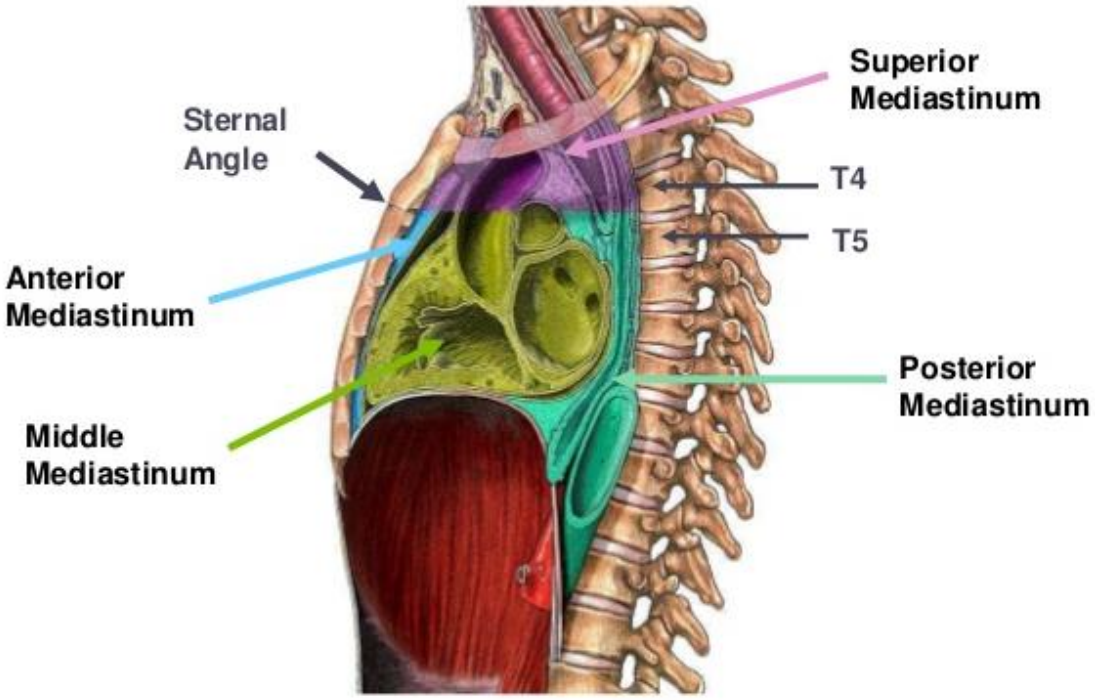
(b) Distribution of bronchiopulmonary segments on lateral surface of lungs

Mediastinum



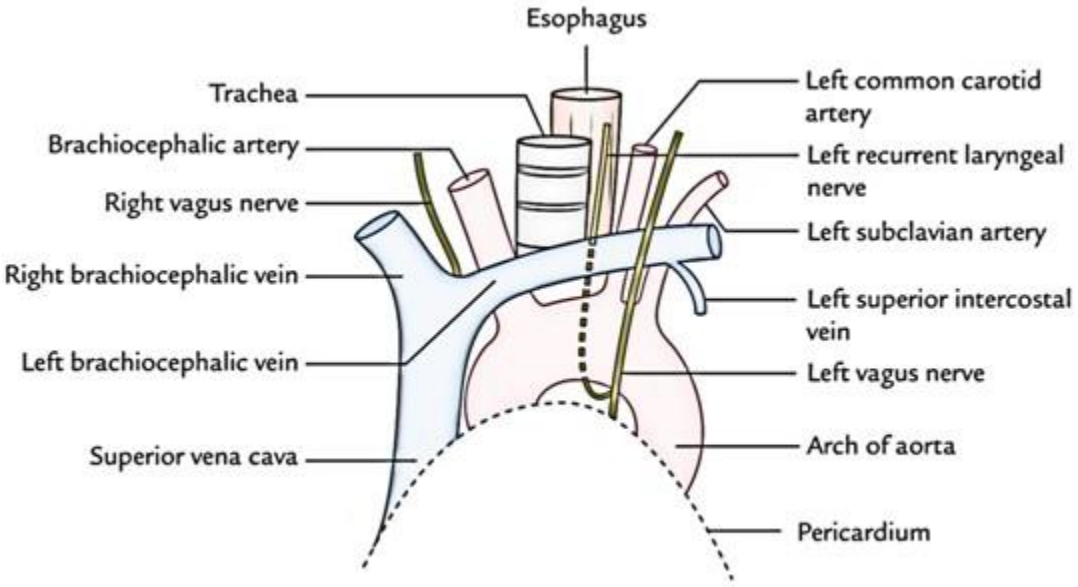
- **Definition:** it's the middle space left in the thoracic cavity between the lungs.
    - The word mediastinum is derived from the Latin word meaning intermediate.
- **Function:** it acts as a passageway for structures such as the esophagus and thoracic duct as they pass to the abdomen.
- **Boundaries:**
    - **Anteriorly:**
        - Sternum
    - **Posteriorly:**
        - Vertebral column
    - **Superiorly:**
        - Thoracic inlet
    - **Inferiorly:**
        - Diaphragm
    - **Laterally on each side:**
        - Mediastinal pleura and the lungs

- **Divisions:**
    - For descriptive purposes the mediastinum is divided into the superior and the inferior mediastinum by an imaginary plane passing through the sternal angle anteriorly and the lower border of the 4th thoracic vertebra posteriorly.
    - The inferior mediastinum is then further divided by the pericardium into;
        - Anterior Mediastinum
        - Middle mediastinum
        - Posterior Mediastinum



- **Contains:**
    - Thymus gland
    - Pericardial sac
    - The heart
    - Trachea
    - Major arteries and veins of the thorax

Superior Mediastinum



- **Boundaries:**
  - **Anteriorly:**
    - Manubrium Sternum
  - **Posteriorly:**
    - Upper four thoracic vertebrae (T1-T4)
  - **Superiorly:**
    - Thoracic inlet
  - **Inferiorly:**
    - An imaginary plane passing through the sternal angel in front and the lower border of the body of the 4th thoracic vertebra behind.
  - **Laterally on each side:**
    - Mediastinal Pleura.
- **Extension:** the superior mediastinum extends upwards, and ends at the superior thoracic aperture.

- **Contents:**
  - **Tubes:**
    - Trachea and Esophagus
  - **Arteries:**
    - Arch of Aorta
    - Brachiocephalic Artery
    - Left Common Cartoid Artery
    - Left Subclavian Artery
  - **Veins:**
    - Right and Left Brachiocephalic Veins
    - Upper half of the Superior Vena Cava
    - Left Superior Intercostal vein
    - Azygos Vein
  - **Nerves:**
    - Vagus
    - Phrenic
    - Cardiac nerves of both side
    - Left Recurrent Laryngeal nerve
  - **Lymph Nodes:**
    - Paratracheal
    - Brachiocephalic
    - Tracheobronchial
  - **Thymus**
  - **Thoracic Duct**

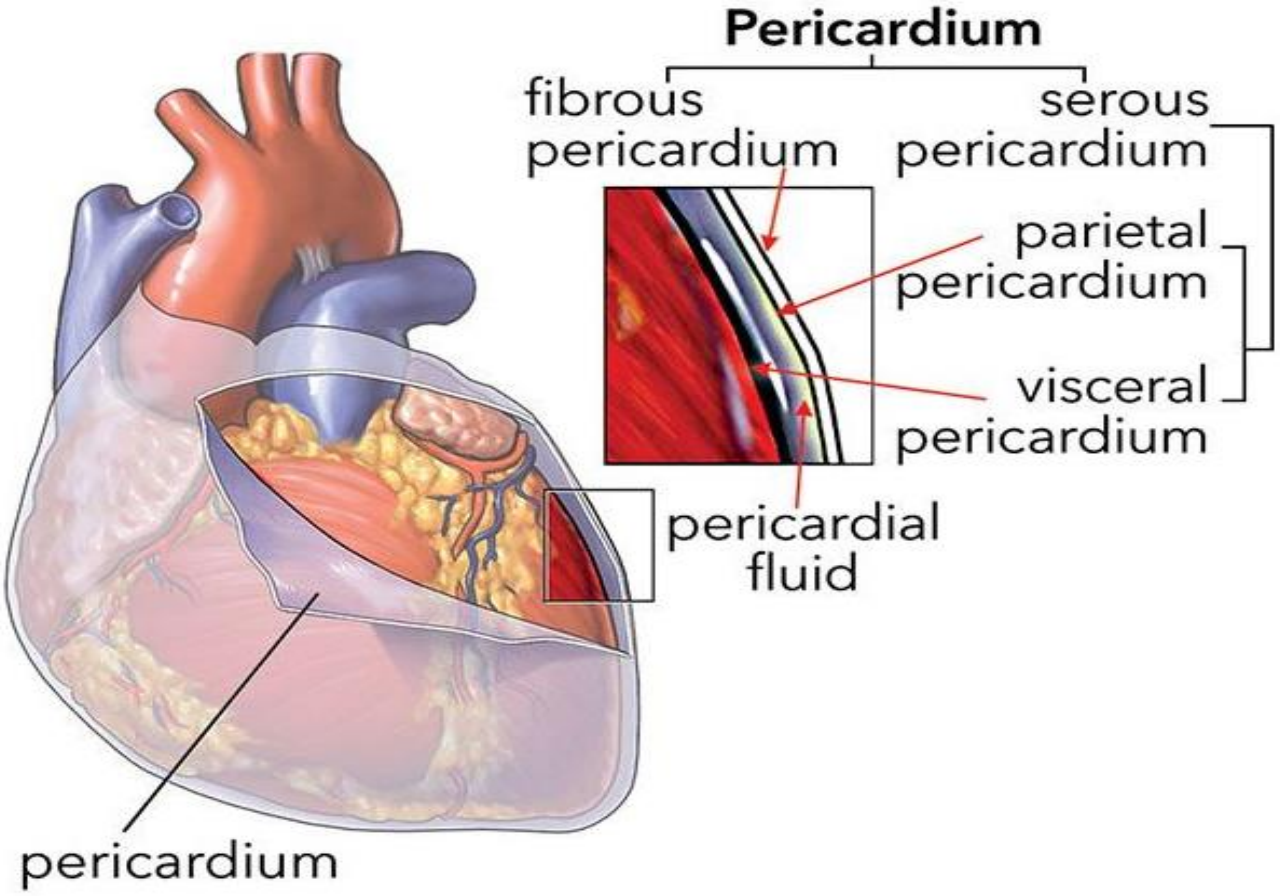
Inferior Mediastinum

- **Anterior Mediastinum**—is a very narrow space in front of the pericardium. It is continuous through the superior mediastinum with the pre-tracheal space of the neck.
    - **Extension:** the anterior mediastinum extends downwards, terminating at the diaphragm.
    - **Boundaries:**
        - **Anteriorly:**
            - Body of Sternum
        - **Posteriorly:**
            - Pericardium
        - **Superiorly:**
            - Imaginary plane/line separating the superior mediastinum from the inferior mediastinum.
        - **Inferiorly:**
            - The diaphragm
        - **Laterally on each side:**
            - Mediastinal pleura.
    - **Contents:**
        - Sternopericardial ligaments
        - Lymph nodes with lymphatics
        - Small mediastinal branches of the internal thoracic artery
        - The lowest part of thymus
        - Areolar tissue

- **Middle Mediastinum**—is centrally located in the thoracic cavity. It is the broadest part of the mediastinum.
    - **Boundaries:**
        - **Anteriorly:**
            - Sternopericardial ligaments
        - **Posteriorly:**
            - Esophagus, descending thoracic aorta, and azygos vein.
        - **Inferiorly:**
            - Superior surface of the diaphragm.
        - **Laterally on each side:**
            - Mediastinal Pleura
    - **Contents:**
        - Heart enclosed in pericardium
        - Ascending Aorta
        - Pulmonary trunk
        - Lower half of the superior vena cava
        - Upper part of Inferior vena cava
        - Terminal part of the azygos vein
        - Right and left pulmonary veins.

- **Posterior Mediastinum**
  - **Boundaries:**
    - **Superiorly:**
      - Continuous with the superior mediastinum.
    - **Anteriorly:**
      - Pericardium
      - Bifurcation of trachea
      - Pulmonary vessels
      - Posterior part of the upper surface of the diaphragm
    - **Posteriorly:**
      - Lower 8 thoracic vertebrae and intervening discs
    - **Inferiorly:**
      - The diaphragm
    - **Laterally on each side:**
      - Mediastinal pleura
  - **Contents:**
    - Esophagus
    - Descending thoracic aorta and its branches
    - Azygos vein
    - Hemiazygos vein
    - Accessory hemiazygos vein
    - Vagus
    - Splanchnic nerves
    - Posterior mediastinal lymph nodes
    - Thoracic duct

Pericardium

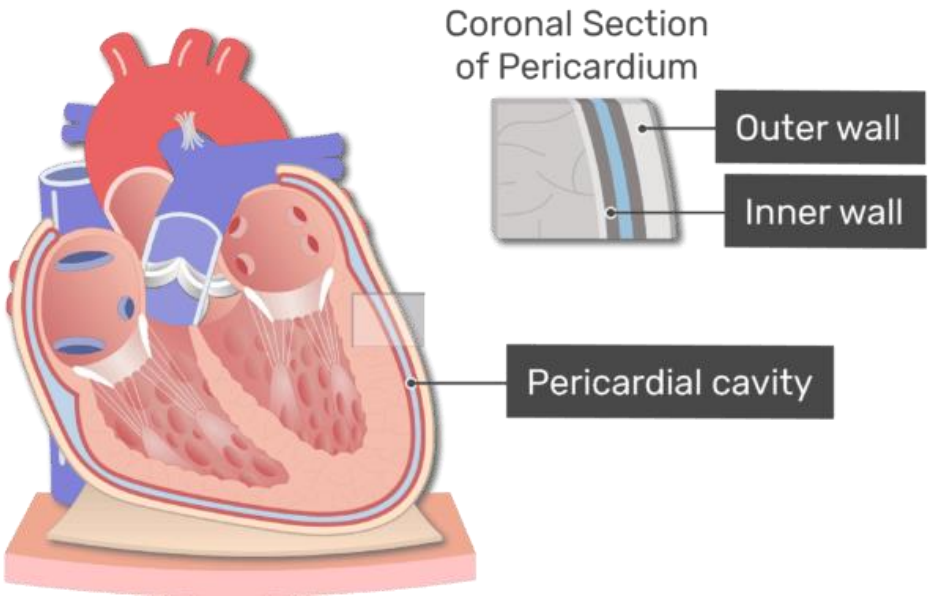


- **Definition:** pericardium is derived from the Greek word meaning “around the heart”, therefore it’s the outer covering of the heart and it’s great vessels. It consists of fibrous and serous layers.
    - **Note:** when discussing the great vessels, we are referring to the ascending aorta, pulmonary trunk, superior and inferior vena cava, and the four pulmonary veins.
- **Location:** it is found in the middle mediastinum surrounding the heart.
- **Layers:**
    - Fibrous Pericardium
    - Serous Pericardium
        - Outer layer—Parietal Pericardium
        - Inner layer—Visceral Pericardium/ epicardium

- ## Fibrous Pericardium
    - **Shape:** cone shaped sac that's made up of fibrous tissue.
    - **Function:** protects the heart against sudden overfilling and prevents over expansion of the heart.
    - **Boundaries:**
        - **Apex**—blunt and lies at the level of the sternal angle.
        - **Base**—is broad and blends with the central tendon of the diaphragm.
        - **Anteriorly:**
            - Connected to the upper and lower ends of the body of sternum by the superior and inferior sterno-pericardial ligaments.
                - This attachment helps the heart to stay in the thoracic cavity.
        - **Posteriorly:**
            - **Related to:**
                - Principle Bronchi
                - Esophagus with nerve plexus around it
                - Descending Thoracic Aorta
        - **On each side:**
            - **Related to:**
                - Mediastinal Pleura
                - Mediastinal surface of the lung
                - Phrenic nerve
                - Pericardaicophrenic vessels

- # Serous Pericardium

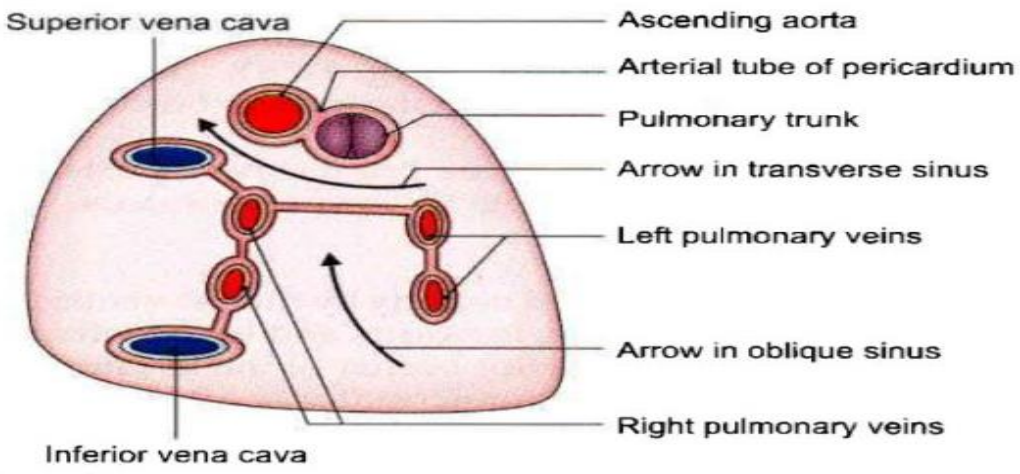
- **Definition:** It's a thin double layered serous membrane that's lined by mesothelial cells.
- Parietal Pericardium is fused or "merged" with the inner surface of the fibrous pericardium.
- Visceral Pericardium is fused to the heart, except along the cardiac grooves which are created by the passage of blood vessels.
- **Pericardial Cavity**—is a potential space between the parietal pericardium and the visceral pericardium.
    - It contains a small amount of fluid, which lubricates the area between the two surfaces allowing the heart to contract/beat smoothly.



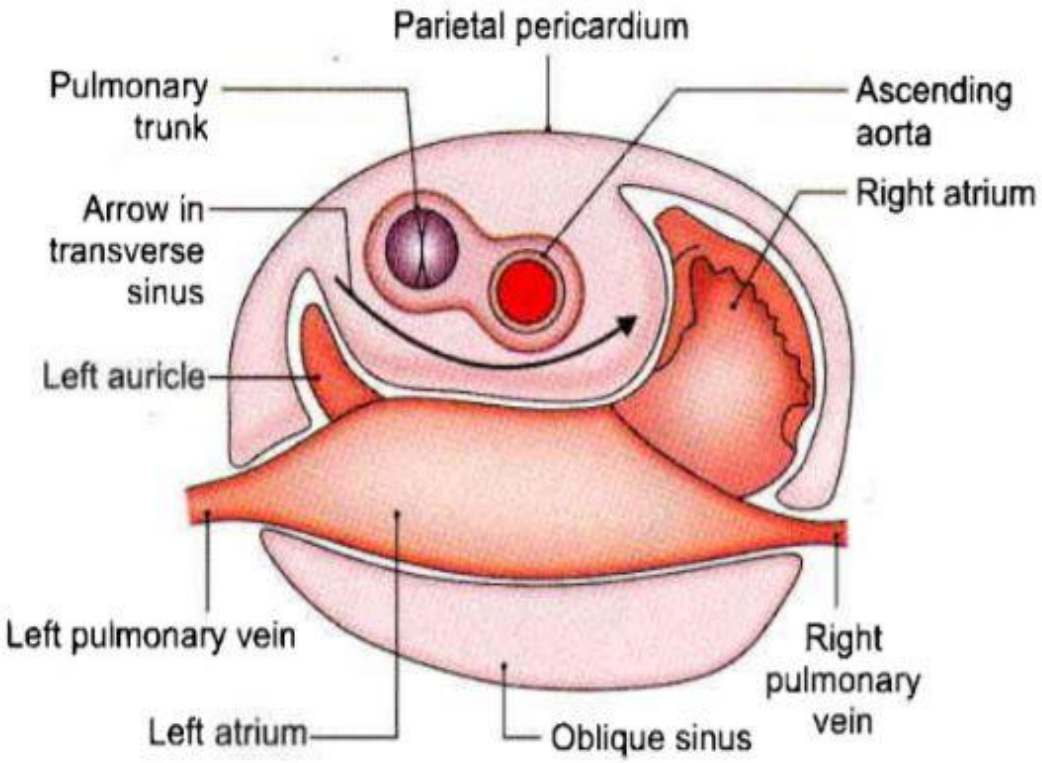
- **Contents of the Pericardium:**
    - Are the heart and the great vessels which are:
        - The ascending aorta
        - Pulmonary trunk
        - Lower ½ of the superior vena cava
        - Terminal part of the inferior vena cava
        - Terminal parts of the pulmonary veins.

• Sinuses of Pericardium

- **Transverse Sinus**—is the passage/horizontal gap found between the arterial and venous ends of the heart tube.
  - The roots of the great vessels are grouped into two tubes.
    - **The Arterial tube:**
      - Contains the ascending aorta and the pulmonary trunk at the atrial end of the hear tube.
    - **The Venous tube:**
      - Contains the inferior and superior vena cava and pulmonary veins at the end of the venous end of the heart tube.
  - **Boundaries of the Transverse Sinus:**
    - **Anteriorly:**
      - Superior Vena Cava
    - **Posteriorly:**
      - Ascending Aorta
      - Pulmonary Trunk
    - **Inferiorly:**
      - Left Atrium
    - **On each side:**
      - Opens into the pericardial cavity.

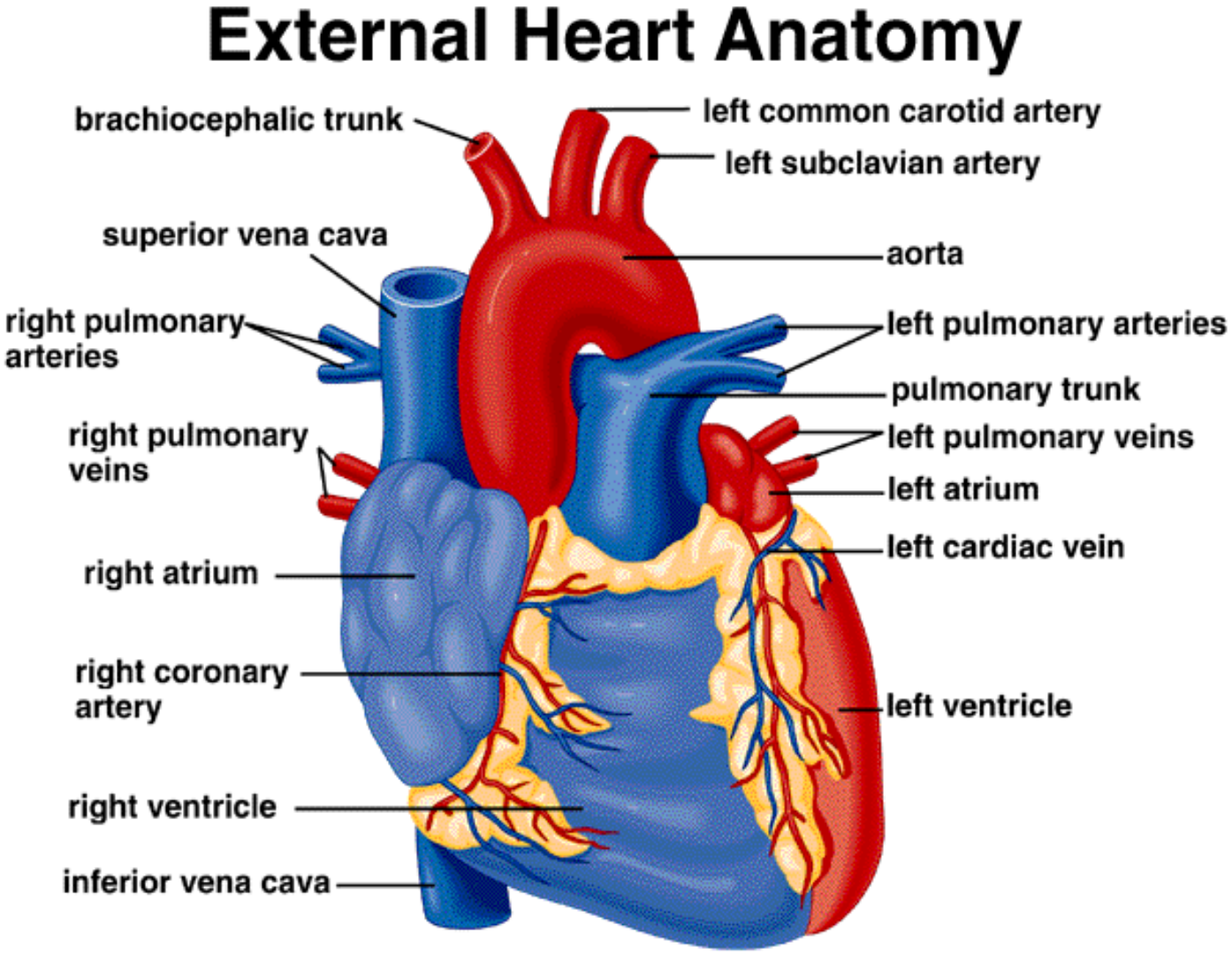


- **Oblique Pericardial sinus**—is the space found between the veins during development. This space is created during the devolvement of the heart because the veins are originally grouped together, but as the heart grows in size the veins separate creating a space which is later called the oblique pericardial sinus.
- **Oblique Sinus**—is a narrow gap found behind the heart.
  - **Function:** allows pulsations of the left atrium to take place freely.
  - **Boundaries:**
    - **Anteriorly:**
      - Left Atrium
    - **Posteriorly:**
      - Parietal Pericardium and Esophagus
    - **Right and Left sides:**
      - Reflections of the pericardium.



- **Blood Supply of the Pericardium:**
  - **The fibrous and parietal pericardia are supplied by branches of:**
    - Internal thoracic
    - Musculophrenic arteries
    - Descending thoracic aorta
- **Venous Drainage:**
  - Veins drain into corresponding veins.
- **Nerve Supply:**

Fibrous and Parietal Pericardium	Visceral Pericardium
Supplied by Phrenic Nerves	Supplied by autonomic nerves
Sensitive to pain	Not sensitive to pain



The Heart

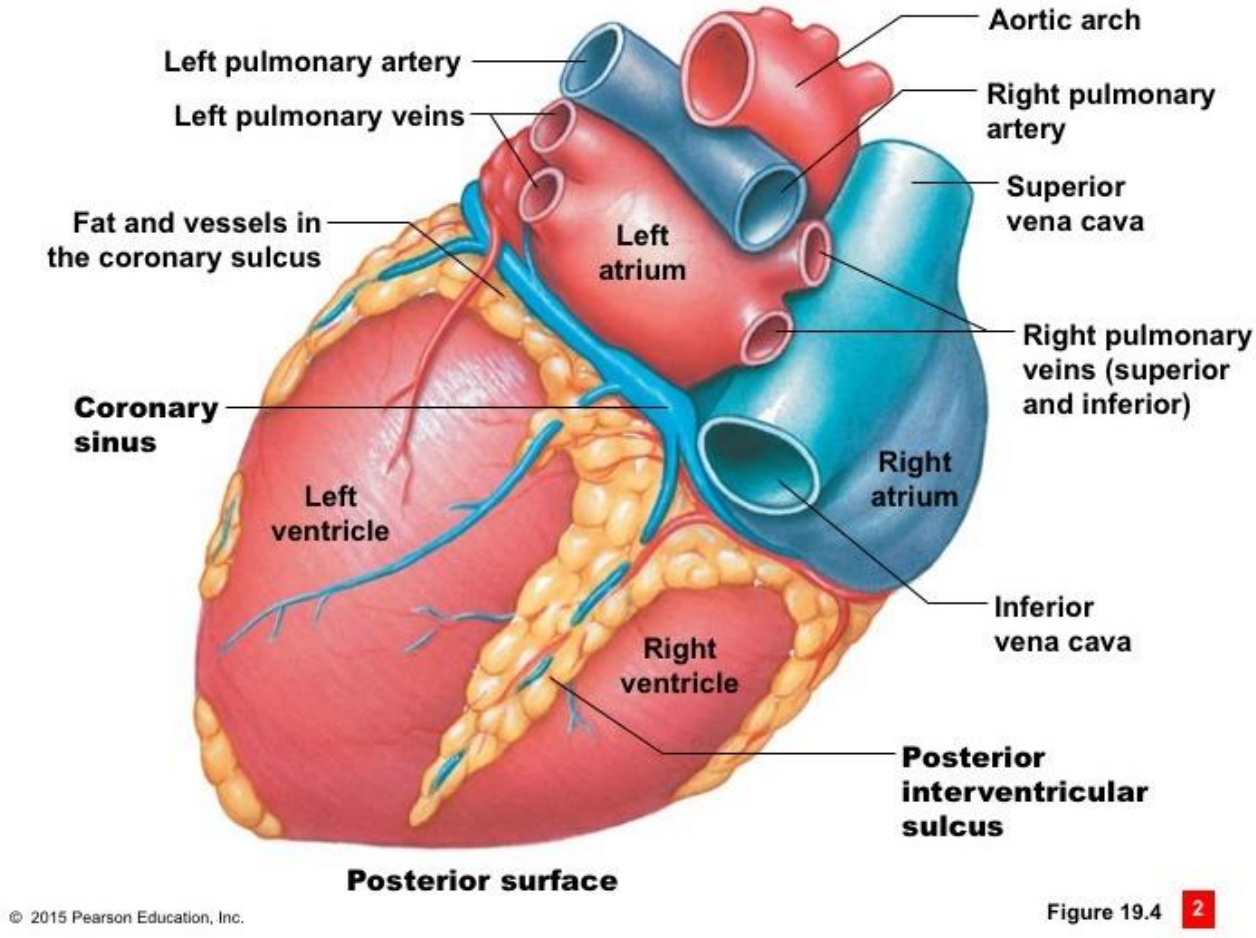


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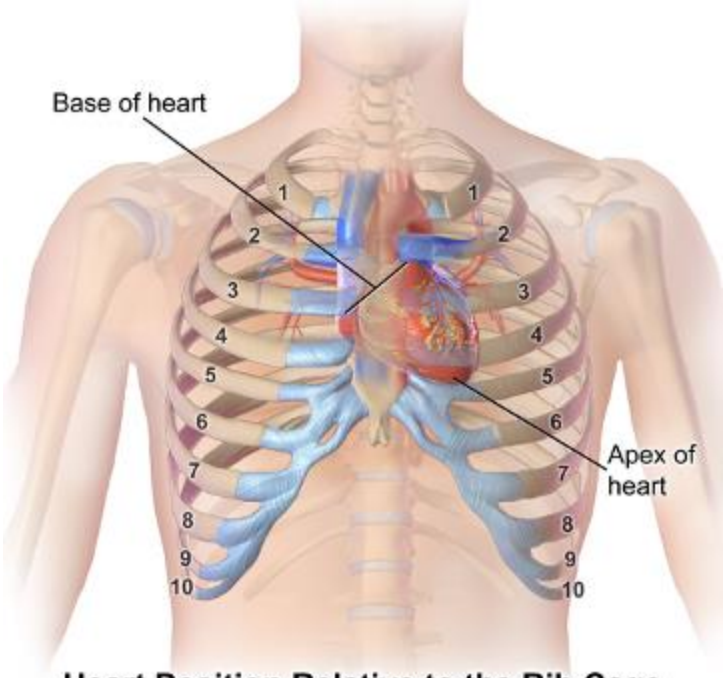
Figure 19.4 2

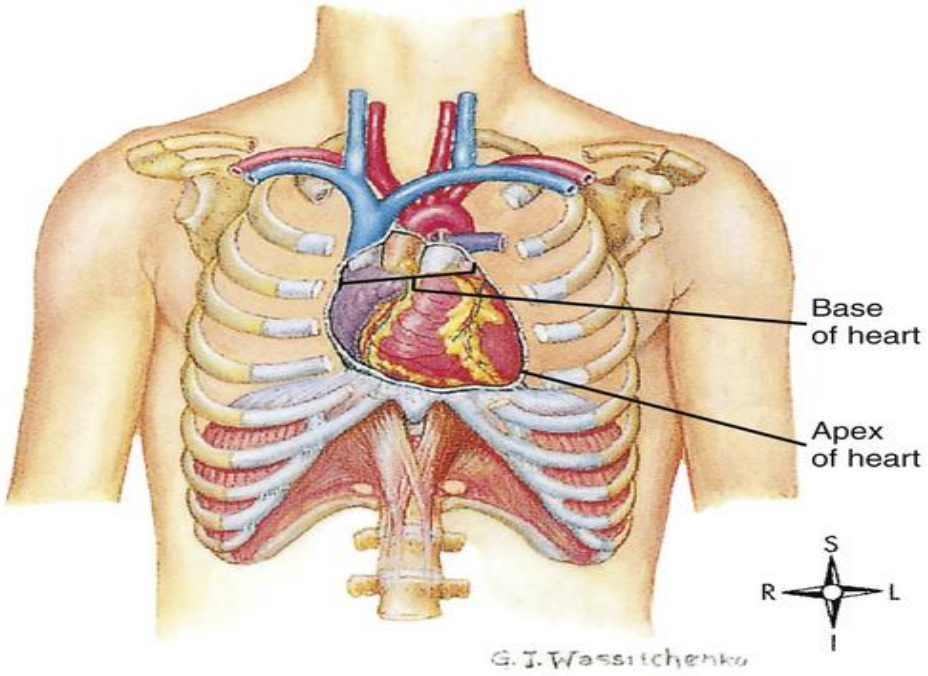
- **Definition:** the heart is a hollow muscular organ that pumps blood to the body.
  - When referring to the heart we use the it's great name "cardia".
- **Shape:** cone shaped
  - **<u>The heart has:</u>**
    - An apex directed downwards, forwards and to the left.
    - A base (posterior surface) directed backwards
    - **<u>Surfaces:</u>**
      - Anterior/sternocostal
      - Interior
      - Left lateral
- **Location:** it's placed obliquely in the middle mediastinum



Heart Position Relative to the Rib Cage

- **Size:** it's a little larger than a person's closed fist.
- **Weight:** 300 grams in males and 250 grams in females.
- **Special Characteristics of the heart:**
    - It has a right and left atrium, and right and left ventricles. Therefore, the heart has a total of 4 chambers.
    - The atria are separated from the ventricles by an atrioventricular groove.
    - The atria are separated from each other by the interatrial groove.
    - The ventricles are separated from each other by the interventricular groove (has an anterior and posterior part)

- **Boundaries of the Heart:**

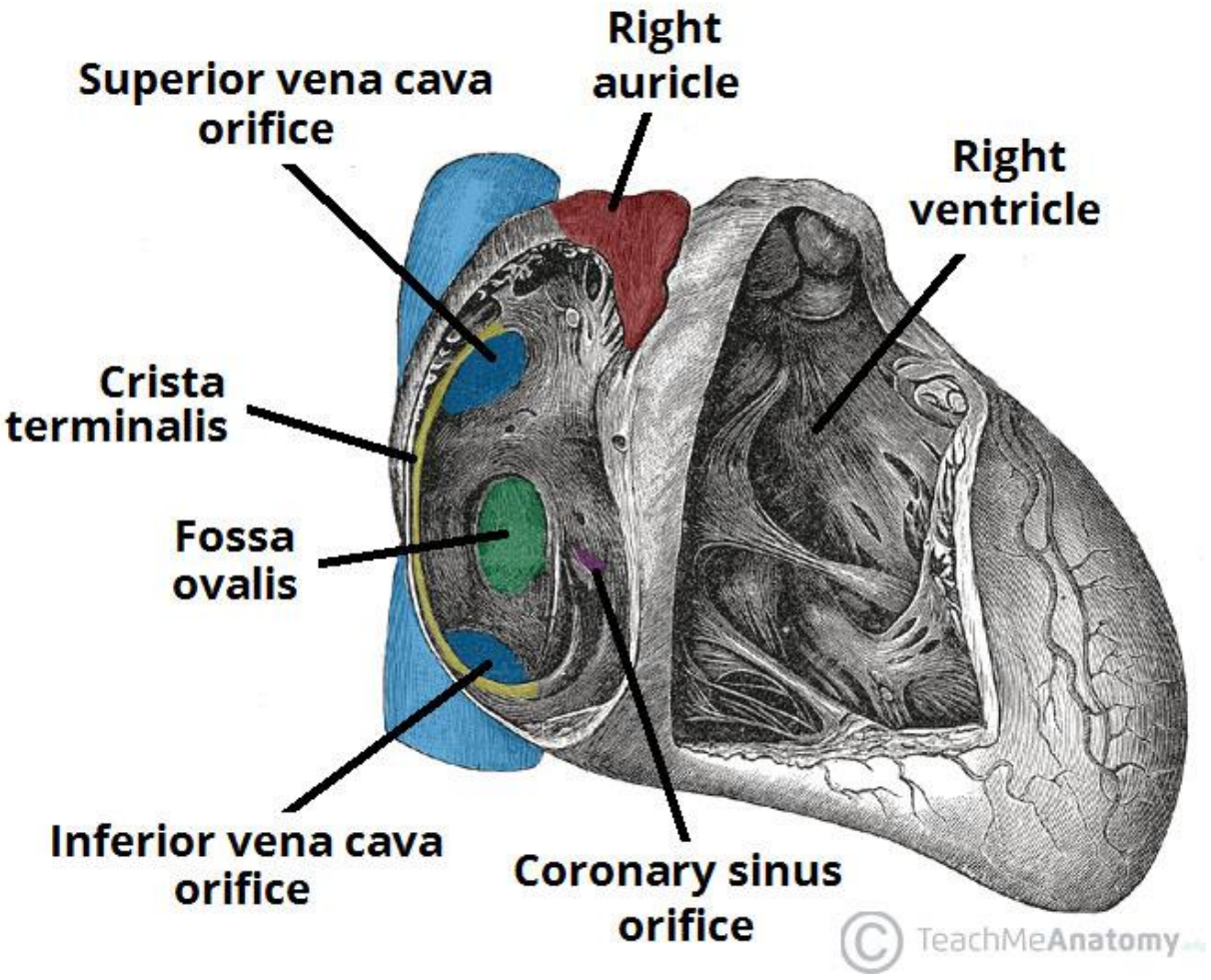


  - **Apex**—it is formed by the inferolateral part of the left ventricle.
    - **Position:** it's situated in the left 5th intercostal space 9cm lateral to the midsternal line.
    - **Note:** in children below 2 years old, the apex of the heart is found in the left fourth intercostal space in the midclavicular line.
  - **Base**—is formed by the left atrium and by a small part of the right atrium.
    - **Position:** is fixed posteriorly opposite the 5th to 8th thoracic vertebrae when lying down, and
    - **Relations:**
      - From the base you can see the opening of the:
        - Four pulmonary veins which open into the left atrium
        - Superior and Inferior vena cava which open into the right atrium.
    - **Separated from the vertebral column by:**
      - Pericardium
      - Right Pulmonary Veins
      - The Esophagus and the Aorta

- **Borders:**
  - **Upper border**—formed by the 2 atria (mainly the left atrium)
  - **Right border**—formed by the right atrium
    - **Extension:** from the superior vena cava to the inferior vena cava.
  - **Inferior border**—formed mainly by the right ventricle.
    - **Extension:** from the inferior vena cava to the apex of the heart.
  - **Left border—**formed mainly by the left ventricle and a small part by the left auricle.
    - **Note:** the left auricle, also known as the left atrial appendage (LAA), is a small muscular pouch at the upper corner of the left atrium. It collects oxygenated blood as it leaves the lungs and moves the blood into the left ventricle.
- **Surfaces:**
  - **Anterior/Sternocostal Surface**—is formed by the right atrium and right ventricle, and a small part by the left ventricle and left auricle.
    - Most of this surface is covered by the lungs, but a part of it that lies behind the cardiac notch of the left lung is uncovered. This uncovered area is called the area of superficial cardiac dullness (because it's dull on percussion/sound).
  - **Inferior/Diaphragmatic surface**—it's formed in its left 2/3rd by the left ventricle and in its right 1/3rd by the right ventricle.
    - **Location:** it sits on the central tendon of the diaphragm.
  - **Left Surface**—is formed mostly by the left ventricle and upper end by the left auricle.
    - **Related to:**
      - Left phrenic nerve
      - Left pericardiophrenic vessels
      - Pericardium

Right Atrium

- **Right Atrium**
  - **Function:** the right atrium receives deoxygenated blood from the superior and inferior vena cava and from the coronary veins (cover the walls of the heart). It pumps this blood through the right atrioventricular orifice into the right ventricle.
    - The atrioventricular orifice is guarded by the tricuspid valve which maintains the flow of the blood in one direction.
  - **Position:** it's the right upper chamber of the heart.
  - **In anatomical position it forms:** the right border, part of the upper border, the sternocostal surface and the base of the heart.



- **Special characteristics:**
  - Upper end Is prolonged to the left to form the right auricle (Latin for little ear)
    - **Note:** The right auricle of the heart - also called the right atrial appendage (RAA) - is attached to the heart's right atrium. It's a small, cone-shaped pouch which comes out from the upper and front part of the atrium and overlaps the root of the aorta. The RAA is very muscular, and is lined with small muscles on its surface. It collects deoxygenated blood from the bloodstream and moves it into the heart's right ventricle, it also acts to increase the capacity of the atrium.
  - ***Sulcus terminalis***—is a shallow vertical groove which passes from the superior vena cava above to the inferior vena cava below along the right border of the atrium.
    - It's formed by an internal muscular ridge called the crista terminalis.
      - The crista terminalis begins on the roof of the atrium just infront of the superior vena cava and extends down to the lateral wall of the anterior lip of the inferior vena cava.
  - ***Atrioventricular groove***—lodges the right coronary artery and the small cardiac vein.
  - ***Interventricular groove***—is represented by a line from the 3rd left sternocostal junction drawn parallel to the left border of the heart till it meets the inferior border.
  - ***Interatrial Septum***—it's a muscular wall that separates the right and left atria.

- ***Fossa Ovalis***—it's a small oval shaped depression found int eh septal wall of the right atrium. It is the remnant of the foramen ovale in the fetal heart.
    - **Function:** it allowed the right to left shunting of the blood to bypass the lungs. It closes once the newborn takes it's first breath.
- ***Coronary Orifice***: receives blood form the coronary veins.
    - It opens into the right atrium between the inferior vena cava and the right atrioventricular orifice.

- **Interior Surface:**
    - The interior surface of the right atrium can be divided into 2 parts, each with a distinct embryological origin. These 2 parts are separated by crista terminalis.
        - **Sinus Venarum**—which is located posterior to the crista terminalis.
            - ***Origin:*** it is derived from the right horn of the sinus venosus.
            - **Function:** This part receives blood from the superior and inferior vena cava.
            - **Feature:** It has smooth walls.

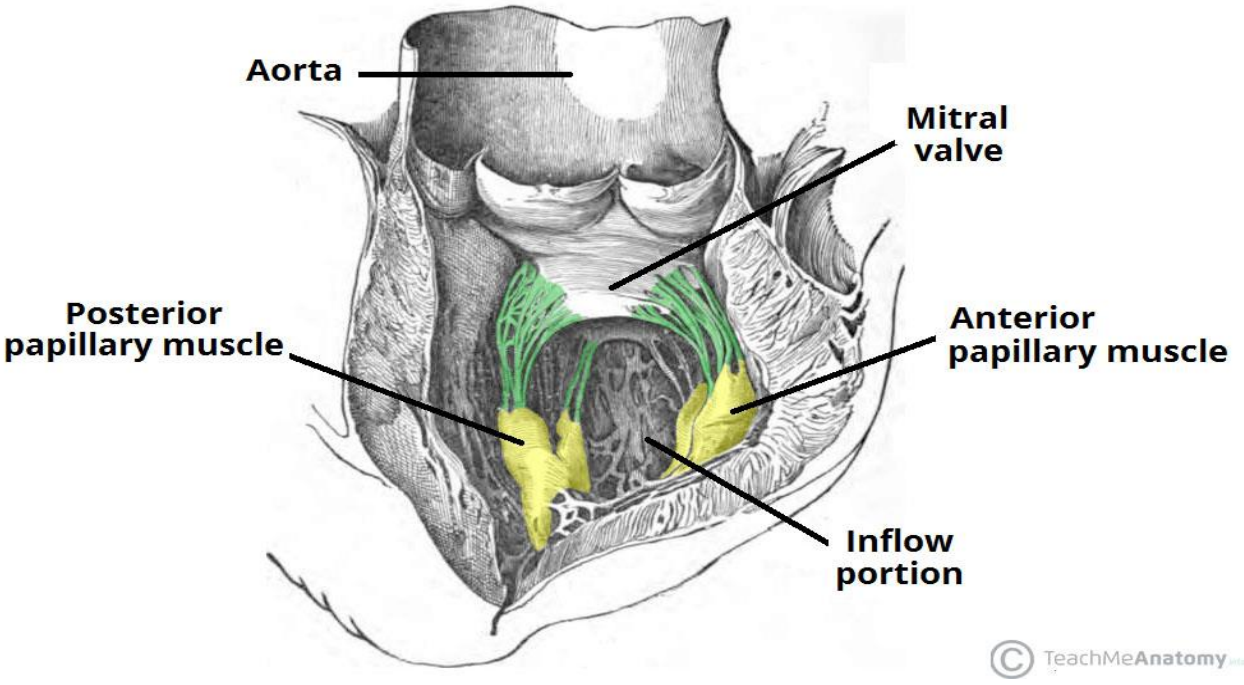
        - **Atrium Proper (Pectinate part)**—located anterior to the crista terminalis and includes the right auricle.
            - **Origin:** it is derived from the primitive atrium.
            - **Features:** it has a rough muscular wall that's formed by pectinate muscles.

Left Atrium

- **Shape:** it is a quadrangular chamber.
- **Location:** it's situated posteriorly.
- **Forms:**
    - 2/3rd of the base/posterior surface of the heart
    - Greater part of the upper border
    - Parts of the sternocostal and left surfaces of the left border
- **Special Characteristic:**
    - It's appendage the left auricle projects anteriorly to overlaps the root of the pulmonary trunk.
    - The anterior wall of the atrium is formed by the interatrial septum.
    - Two pulmonary veins open into the atrium on each side of the posterior wall.
- **The left atrium is derived from 2 structures:**
    - **Posterior half/Inflow portion/Greater part of the left atrium:**
        - Atrium's interior wall is smooth and receives the 4 pulmonary veins.
        - ***Origin:*** it is derived embryologically from the absorbed pulmonary veins which open into it.
    - **Anterior half/Outflow portion/ smaller part of the left atrium:**
        - Atrium's interior wall is lined by pectinate muscles
        - ***Origin:*** derived from the embryonic primitive atrium.
            - **Note:** it includes the left auricle.
- **Note:** There is no distinct structures which separates the 2 parts like in the right atrium.

Table 18.2: Comparison of right atrium and left atrium

Right atrium	*Left atrium*
Receives venous blood of the body	Receives oxygenated blood from lungs
Pushes blood to right ventricle through tricuspid valve	Pushes blood to left ventricle through bicuspid valve
Forms right border, part of sternocostal and small part of base of the heart	Forms major part of base of the heart
Enlarged in tricuspid stenosis	Enlarged in mitral stenosis



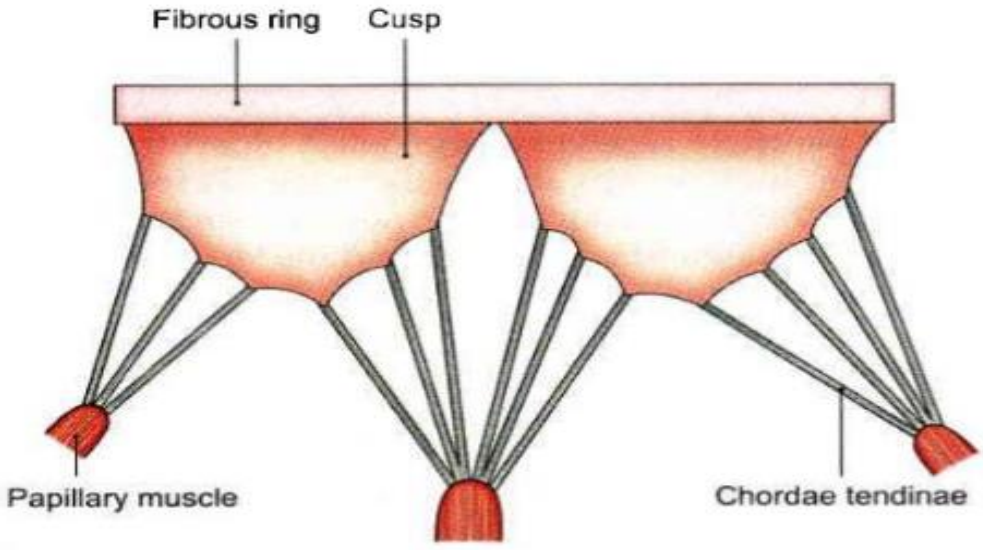
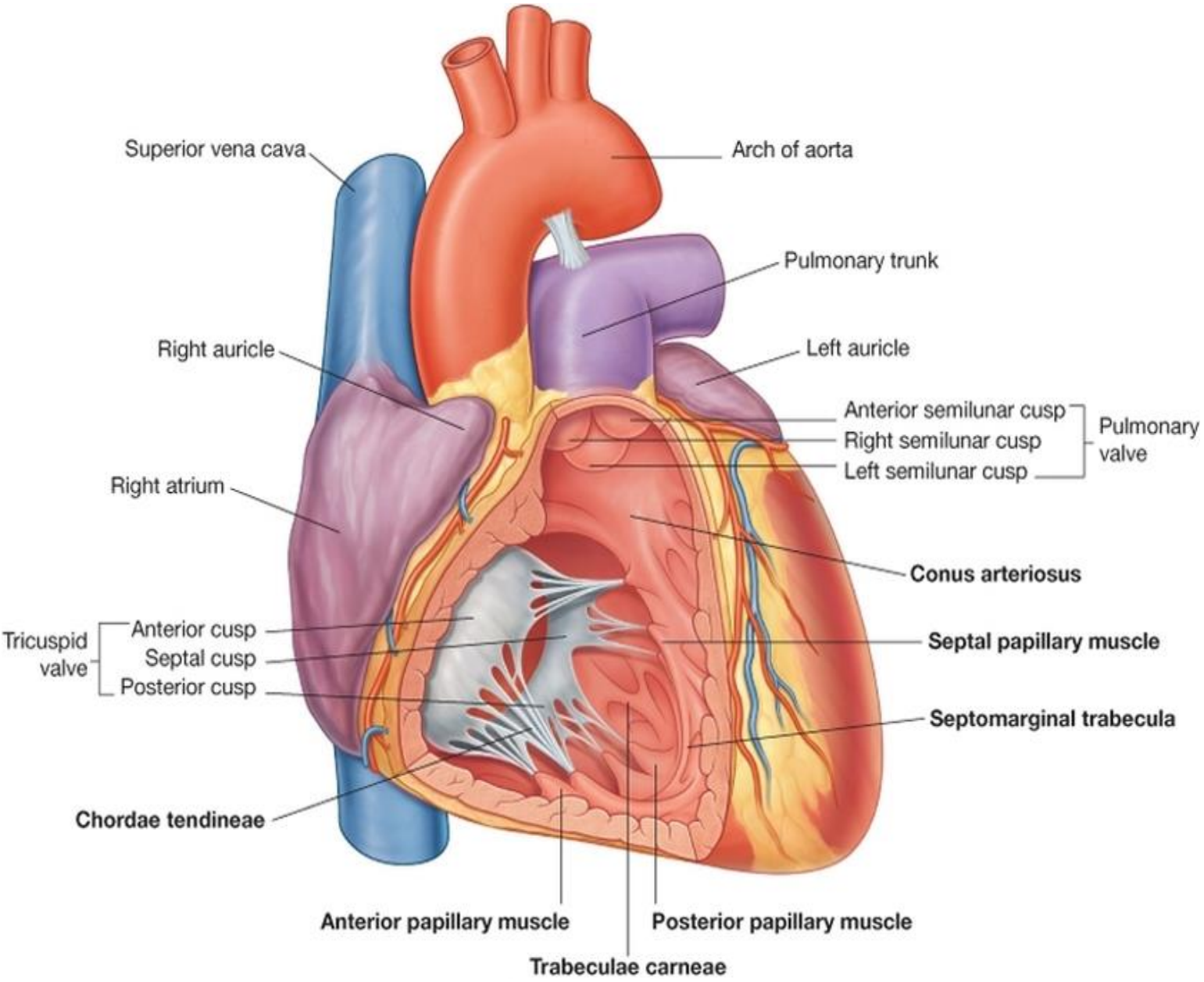


Fig. 18.13: Structure of an atrioventricular valve

Right Ventricle

- **Shape:** triangular chamber
- **Function:** receives deoxygenated blood from the right atrium and pumps it through the pulmonary orifice into the pulmonary artery.
    - The pulmonary orifice is guarded by the pulmonary valve.
- **Forms:**
    - Inferior border of the heart
    - Sternocostal surface of the heart
- **Special Characteristics:**
    - **External surfaces:**
        - Anterior/Sternocostal surface
        - Inferior/Diaphragmatic
    - **Interior Surface is divided/separated into 2 parts by a muscular ridge called supraventricular crest into:**
        - ***Inflowing part***—which is rough because of the presence of muscular ridges called trabeculae corneae.
            - Develops from the proximal part of bulbus cordis of the heart tube.
        - ***Outflowing part/Infundibulum***—which is smooth and forms the upper conical part of the right ventricle giving rise to the pulmonary trunk.
            - Develops from the mid portion of the bulbus cordis.
    - **Note:**
        - The supraventricular crest is found between the tricuspid and pulmonary orifices.
        - The bulbus cordis contains smooth walls, and no trabeculae carneae.
        - The Trabeculae Carneae has 3 main groups of muscles
            - Ridges also known as fixed elevations
            - Bridges
            - Pillars/papillary muscles

- **Interventricular Septum:**
  - ***Site:*** it sits obliquely, its specific location is indicated by the anterior and posterior interventricular grooves.
  - ***Upper part:*** thin and membranous
    - ***Function:*** separates the right and left ventricles as well as the right atrium and left ventricle.
  - ***Lower part:*** thick and muscular
    - Function: separates the two ventricles.

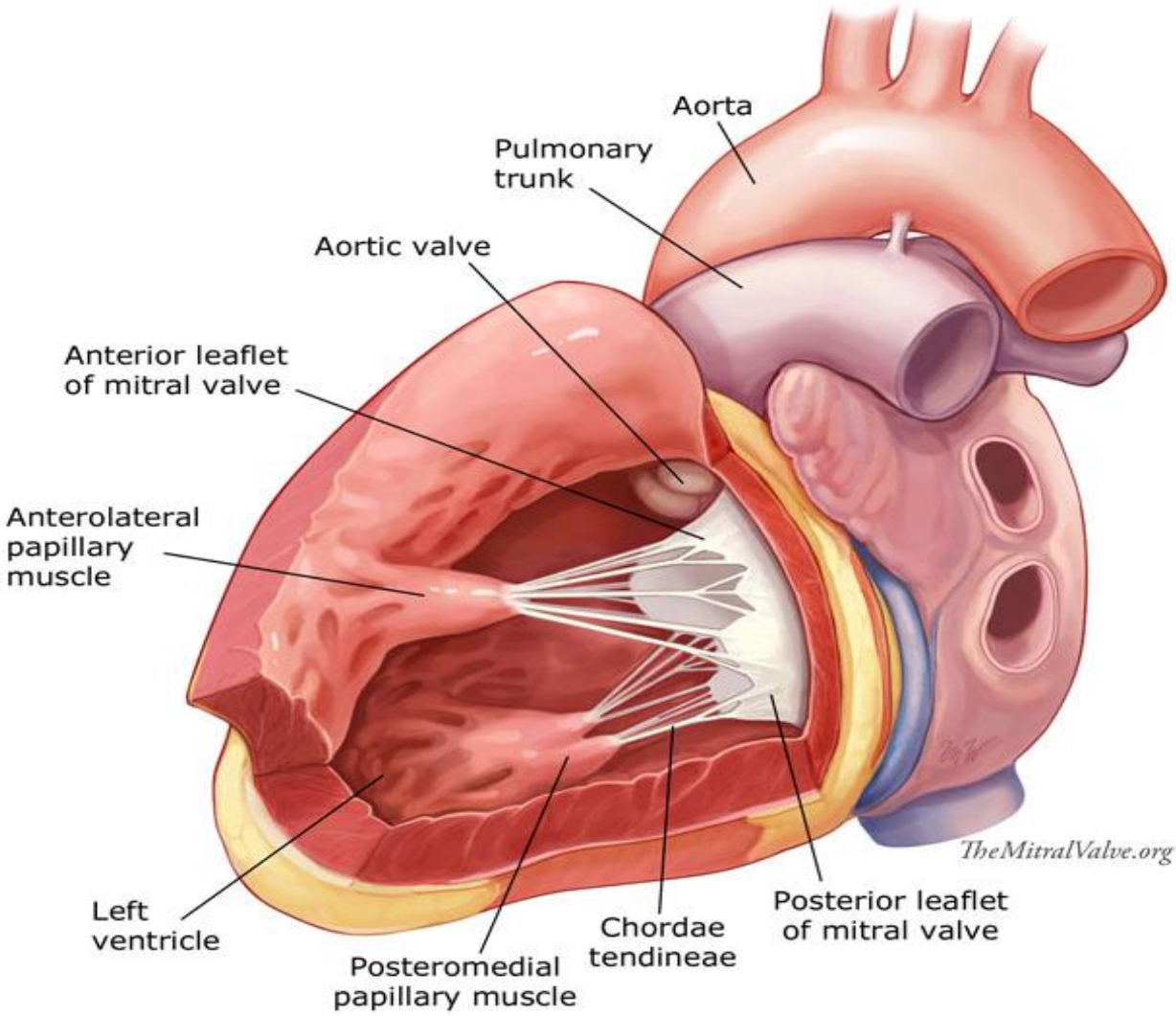


Left Ventricle

- **Function:** receives oxygenated blood from the left atrium and pumps it into the aorta.
- **Forms:**
  - Apex of the heart
  - Part of the sternocostal surface
  - Most of the left border and left surface
  - Left 2/3rds of the diaphragmatic surface
- **Special Characteristics:**
  - **External surfaces:**
    - Anterior/Sternocostal surface
    - Inferior/Diaphragmatic surface
    - Left Surface
  - **Interior surface is divided into 2 parts:**
    - ***Lower part/Inflow portion***—is rough with trabeculae carnea
      - Develops from the primitive ventricle of the heart tube.
    - ***Upper part/outflow/aortic vestibule***—is smooth
      - Gives origin to the ascending aorta.
      - Develops from the mid portion of the bulbus cordis.
  - **Contains two orifices:**
    - Left atrioventricular/bicuspid/mitral orifice guarded by the bicuspid/mitral valve.
    - Aortic orifice, guarded by the aortic valve.

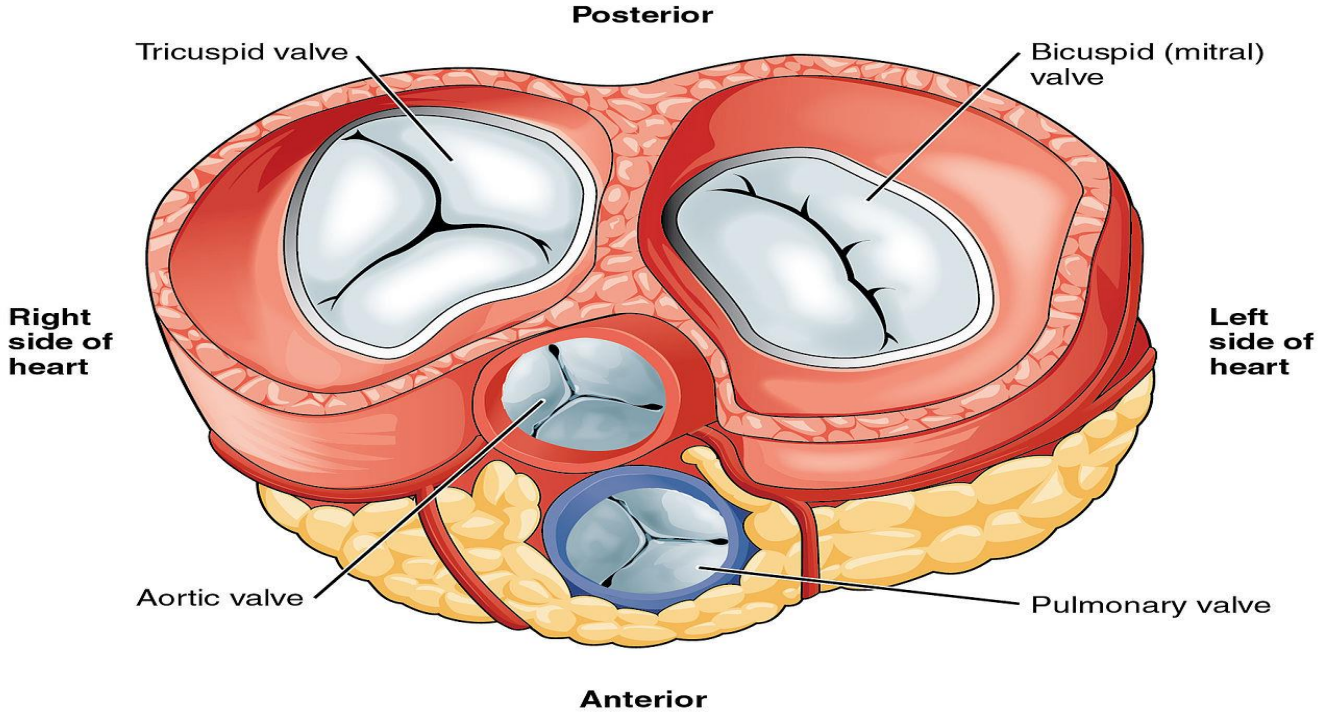
Table 18.3: Comparison of right ventricle and left ventricle

Right ventricle	*Left ventricle*
Thinner than left, 1/3 thickness of left ventricle	Much thicker than right, 3 times thicker than right ventricle
Pushes blood only to the lungs	Pushes blood to top of the body and down to the toes
Contains three small papillary muscles	Contains two strong papillary muscles
Cavity is crescentic	Cavity is circular
Contains deoxygenated blood	Contains oxygenated blood
Forms 2/3rd sternocostal and 1/3rd	Forms 1/3rd sternocostal and 2/3rd diaphragmatic surfaces



Valves of the Heart

- **Definition:** the valves of the heart are structures that prevent back flow of the blood.
    - Therefore, they allow blood to flow in one direction.
- **Formation:** they are formed of connective tissue and endocardium (which is the inner layer of the heart).
- **Divisions:**
    - **Two Atrioventricular valves:**
        - Left atrioventricular valve is called—bicuspid/mitral valve
        - Right atrioventricular valve is called—tricuspid valve
        - **Location:**
            - Found between the atria and the ventricles.
    - **Two Semilunar valves:**
        - Aortic valve
        - Pulmonary valve
        - **Location:**
            - Found between the ventricles and outflow vessels.



Atrioventricular Valves

Bicuspid/Mitral Valve	Tricuspid Valve
• Located between the left atrium and left ventricle.	• Located between the right atrium and the right ventricle
• Consists of 2 cusps (anterior and poster). • The base of each cusp is secured to a fibrous ring that surrounds the orifice.	• Consists of 3 cusps (anterior, septal, and posterior). • The base of each cusp is anchored to a fibrous rig that surrounds the orifice.

• The atrioventricular valves are supported by the attachment f chordae tendineae to the free edges of the valve cusps.
  ○ The chordae tendineae are then attached to papillary muscles that are located on the interior surface of the ventricles.
  ▪ These muscles contract during ventricular systole to prevent prolapse of the valve leaflets into the atria.
• **Note:** the atrioventricular valves are closed during ventricular systole.	

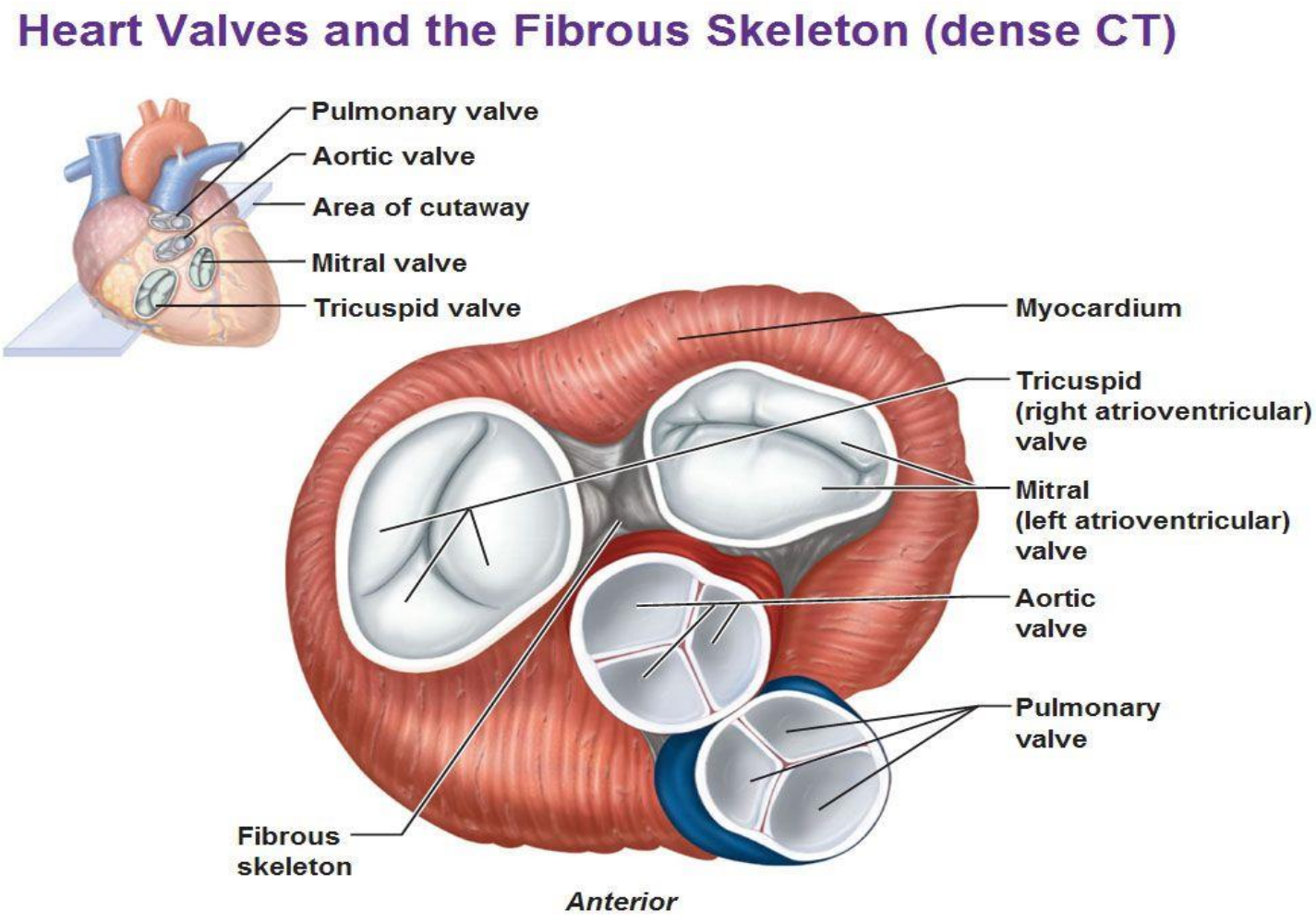
Semilunar Valves

Pulmonary Valve	Aortic Valve
Located between the right ventricle and pulmonary trunk.	Located between the left ventricle and the ascending aorta.
Consists of 3 cusps (left, right and anterior).	Consists of 3 cusps (right, left and posterior).

- The sides of each valve leaflet of the Semilunar Valves are attached to the walls of the outflow vessels, which are slightly dilated to form a sinus.
- The free superior edge of each leaflet is thickened (forming the lunule) and it is widest int eh midline (nodule).
- **Note:**
  - Do not contain fibrous rings
  - Semilunar valves are closed during ventricular diastole.

Fibrous Skeleton

- **Definition:** it is a fibrous tissue which surrounds the atrioventricular orifices.
- **Significance:** origin of the big arteries, the aorta and pulmonary trunk.
    - It also provides attachment to the cardiac muscle and keeps the Cardiac valve competent.
- **Note:** there is no muscular continuity between the atria and ventricles across the rings except for the atrioventricular bundle/bundle of His.
- **There are 2 masses of fibrous tissue:**
    - **Trigonum Fibrosum Dextrum**—is a large mass of fibrous tissue that's found between the atrioventricular rings behind and the aortic ring in-front.
    - **Trigonum Fibrosum Sinistrum**—is the smaller mass of fibrous tissue that is found between the aortic and mitral rings.



Conducting System of the Heart

- **Definition:** the conducting system of the heart is made up of myocardium that is specialized for initiating and conducting the cardiac impulse.
- **The conducting system is made up of the following parts:**
    - Sinoatrial node or SA node
    - Atrioventricular node or AV node
    - Atrioventricular bundle or AV bundle/bundle of His
        - Right Branch of bundle of His
        - Left branch of bundle of His
    - Purkinje fibers

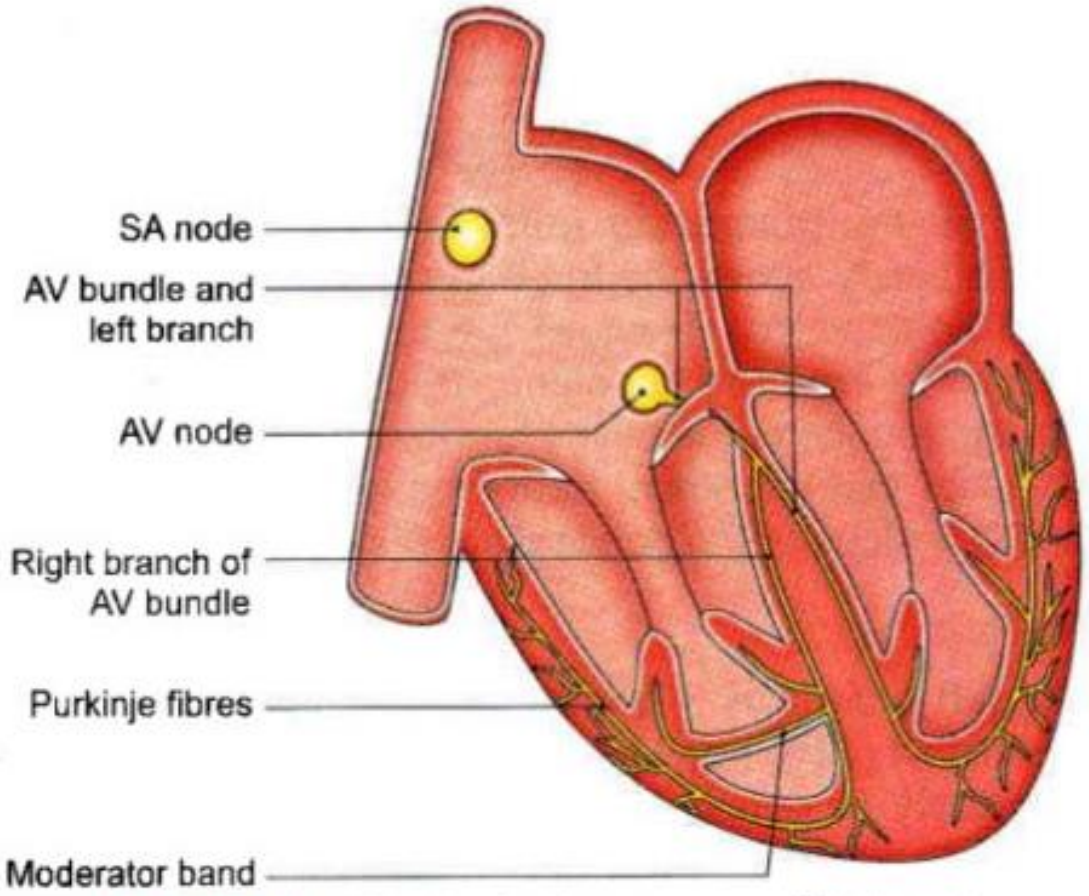
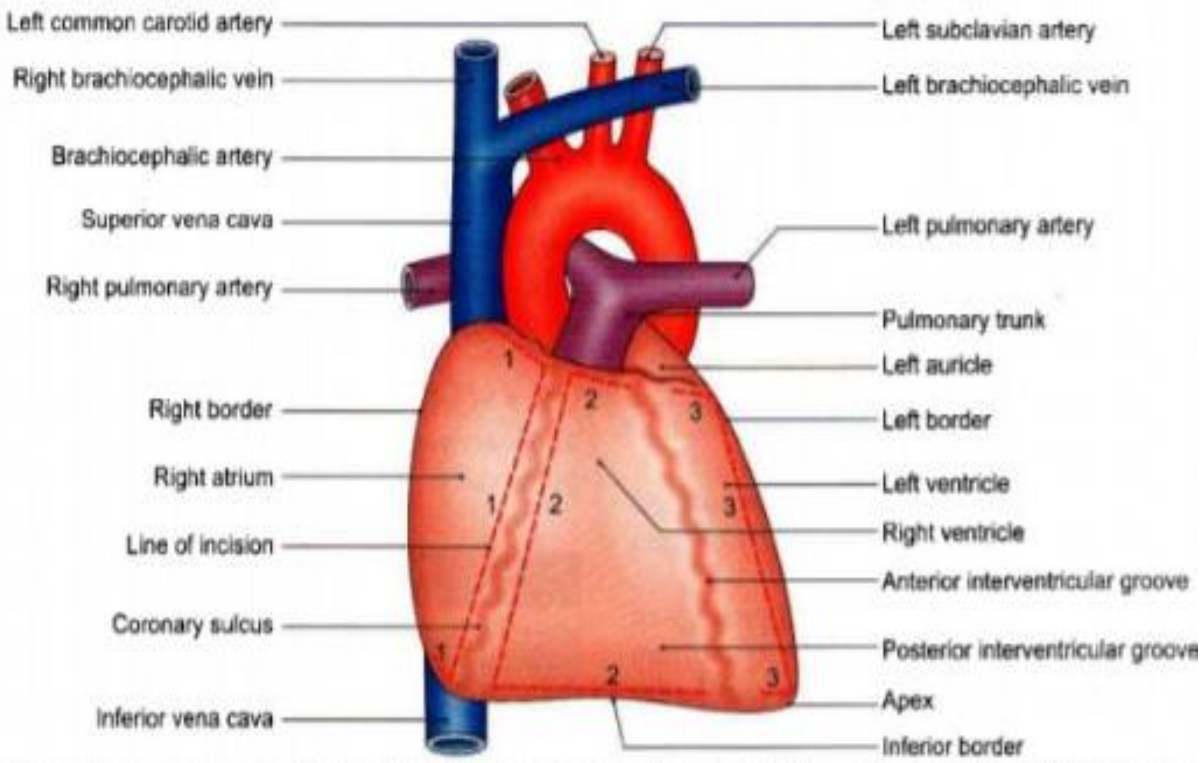


Fig. 18.14: The conducting system of the heart

Table 18.1: Comparing the systemic circulation and pulmonary circulation

Systemic circulation	*Pulmonary circulation*
Left ventricle	Right ventricle
Aortic valve	Pulmonary valve
Aorta	Pulmonary trunk and pulmonary arteries
Oxygenated blood to all tissues except lungs	Only to lungs
Venous blood collected	Deoxygenated blood gets oxygenated
Superior vena cava and inferior vena cava	4 pulmonary veins
Right atrium	left atrium



Arterial Supply of the Heart

1. Right Coronary Artery

- **Begins:** it arises from the anterior aortic sinus of the ascending aorta.
- **Ends:** by anastomosing with the circumflex branch of the left coronary artery at the crux.
    - **Note:** the crux is the area on the lower back side of the heart where the coronary sulcus (the groove separating the atria from the ventricles) and the posterior interventricular sulcus (the groove separating the left from the right ventricle) meet.
- **Branches:**
    - Marginal
    - Posterior interventricular
    - Right atrial
    - Infundibular
    - Terminal
    - Right ventricular
    - Conus
    - Nodal is only present in 60% of cases

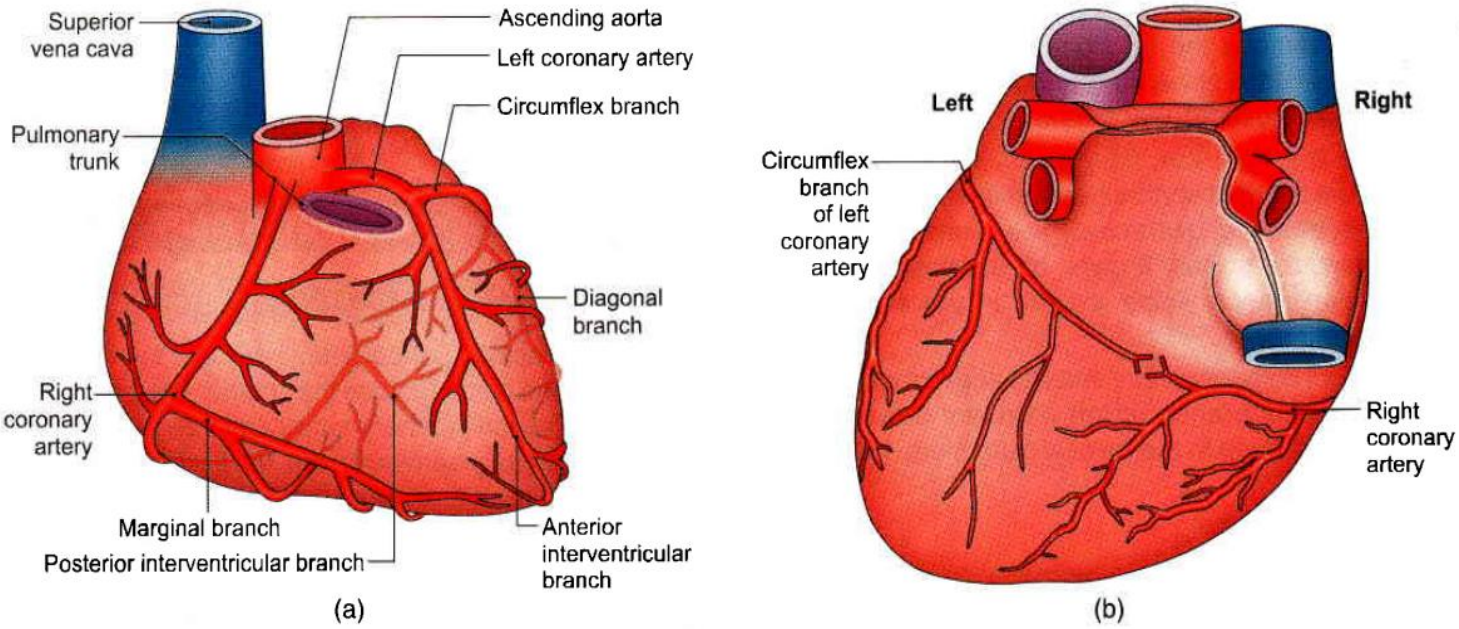
2. Left Coronary Artery

- **Begins:** it arises from the posterior aortic sinus of the ascending aorta.
- **Ends:** it terminates near the posterior interventricular groove by anastomosing with the right coronary artery
- **Note:** the continuation of the left coronary artery is called the circumflex artery.
- **Branches:**
    - Anterior Interventricular
    - Branches to the diaphragmatic surface of the left ventricle, including a large diagonal branch.
    - Left atrial
    - Pulmonary
    - Terminal.

Distribution of the Right and Left Coronary Arteries

Right Coronary Artery	Left Coronary Artery
• Right Atrium • Greater part of the right ventricle, except the area adjoining the anterior interventricular groove. • A small part of the left ventricle adjoining the posterior interventricular groove. • Posterior part of the interventricular septum. • The whole conducting system of the heart except a part of the left branch of the AV Bundle.	• Left Atrium • Greater part of the left ventricle, except the area adjoining the posterior interventricular groove. • A small part of the right ventricle adjoining the anterior interventricular groove. • Anterior part of the interventricular septum. • Part of the left branch of the AV bundle

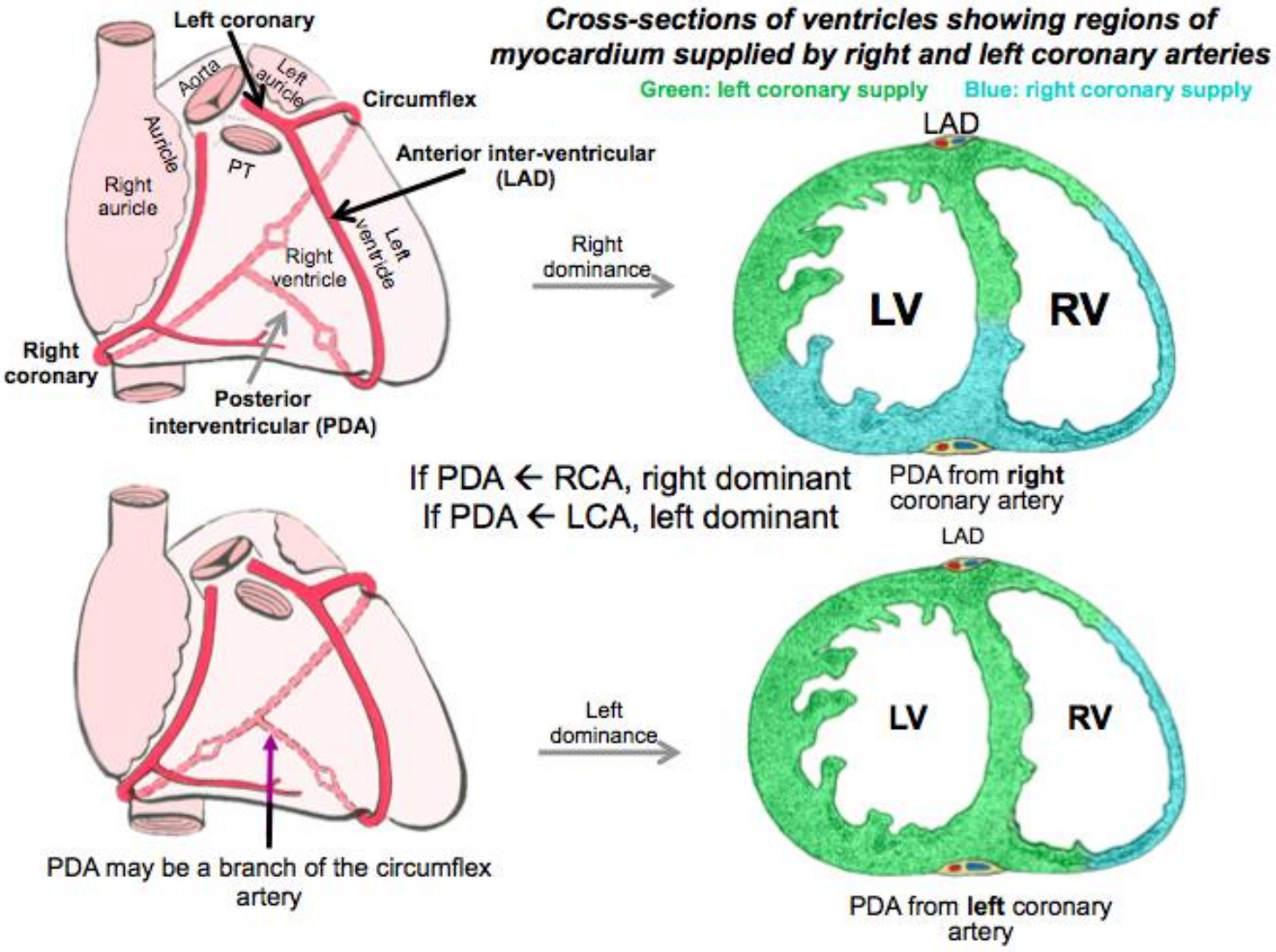
Note: The SA node is supplied by the left coronary artery in about 40% of cases.



Figs 18.22a and b: Arterial supply of heart: (a) Sternocostal surface, and (b) diaphragmatic surface

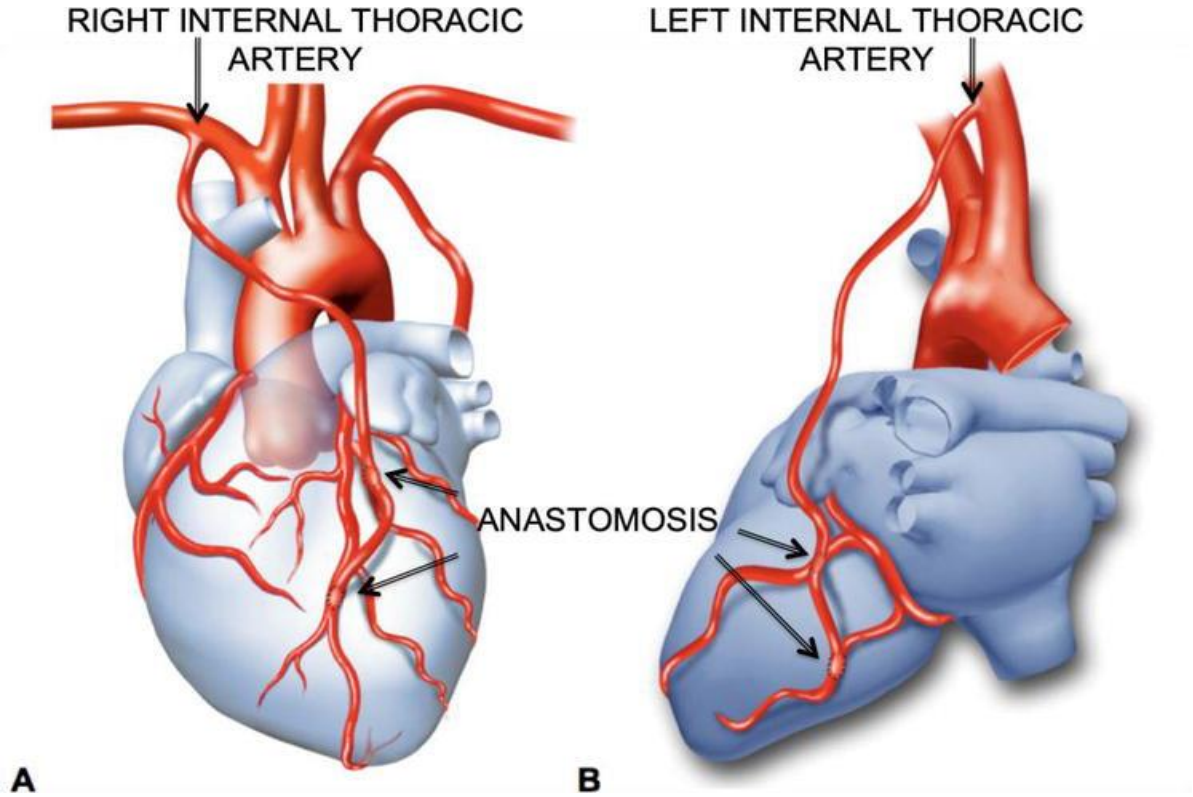
Cardiac Dominance

- **Definition:** Cardiac Dominance depends on which artery the right and left coronary artery supply/give branch to the posterior interventricular branch is considered the dominant artery.
- **For example:**
    - If the right coronary artery gives the posterior interventricular artery, then the heart would be considered right dominant.
    - The same applies if the circumflex artery, the continuation of the left coronary artery provides the posterior interventricular artery it would be considered left dominant.



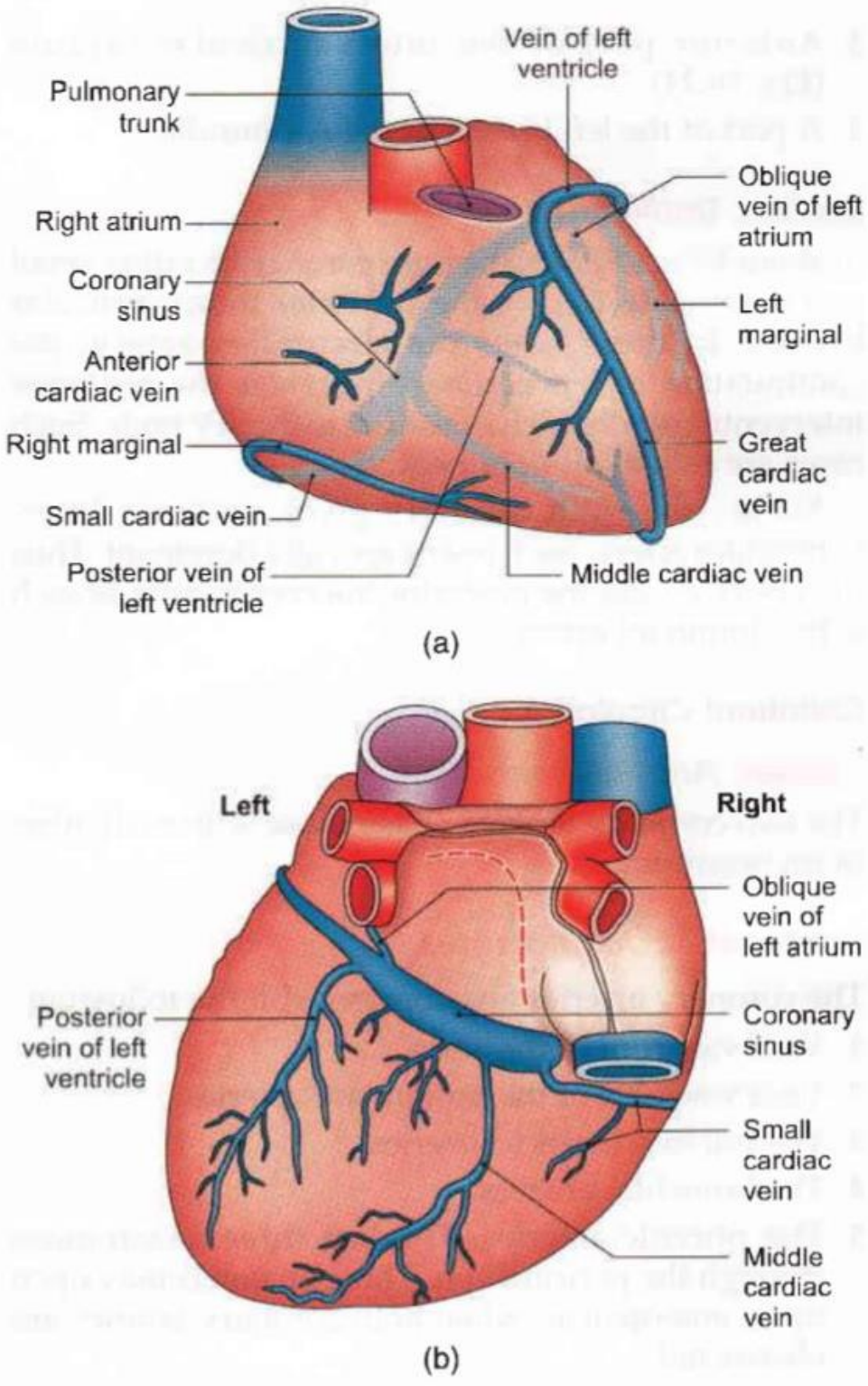
Anastomoses of the Heart

- **Cardiac Anastomoses:**
  - Occurs between the 2 coronary arteries in the myocardium.
- **Extracardiac Anastomoses:**
  - ***The coronary arteries anastomose with:***
    - Vasa Vasorum of the aorta
    - Vasa vasorum of the pulmonary arteries
      - The above arteries anastomose in the myocardium
    - The internal thoracic arteries
    - The bronchial arteries
    - The phrenic arteries
      - The 3 above arteries anastomose through the pericardium
      - **Note:** these channels may open in emergencies when both coronary arteries are obstructed.
  - These anastomoses are not able to provide an alternative source of blood in case one of the coronary arteries are blocked.



Veins of the Heart

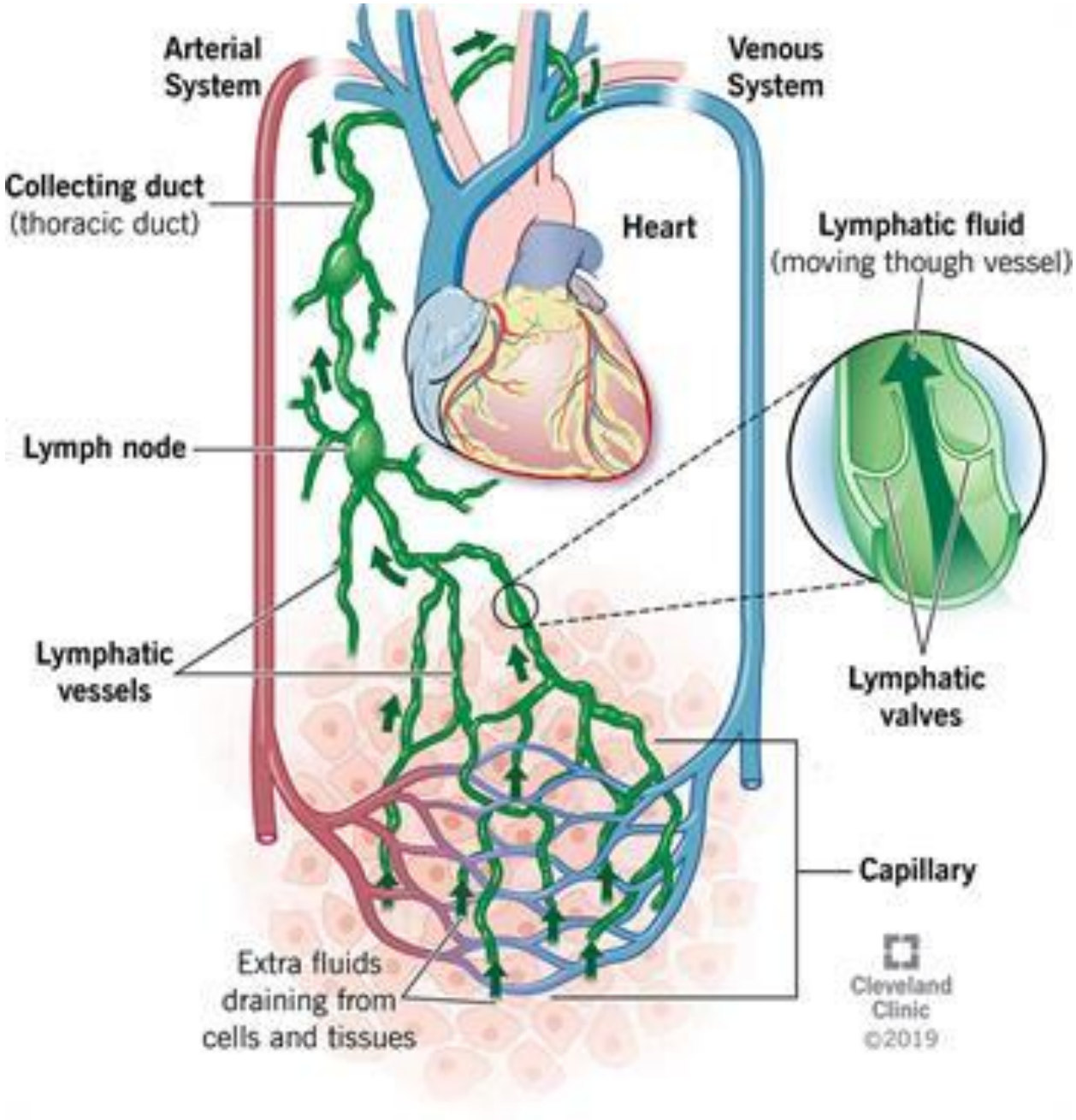
1. **Coronary Sinus**
    - **Definition:** is the largest vein of the heart.
    - **Location:** situated in the left posterior coronary sulcus.
    - **Length:** 3cm long.
    - **Tributaries:**
        - Great Cardiac Vein
        - Middle Cardiac Vein
        - Small Cardiac Vein
        - Posterior vein of the left ventricle
        - Oblique vein of the left atrium of Marshall
        - Right Marginal vein
2. **Anterior Cardiac Veins**
    - **Definition:** are 3 or 4 small veins which run parallel to one another on the anterior wall of the right ventral.
    - **Ends:** by opening directly into the right atrium through its anterior wall.
3. **Venae Cordis Minimi**
    - **Definition:** are numerous small valveless veins found in all four chambers of the heart.
    - **End:** they open directly into the cavity.
    - **Note:** these veins are more common and numerous on the right side of the heart than on the left side.



Figs 18.29a and b: Veins of the heart: (a) Sternocostal surface, and (b) diaphragmatic surface

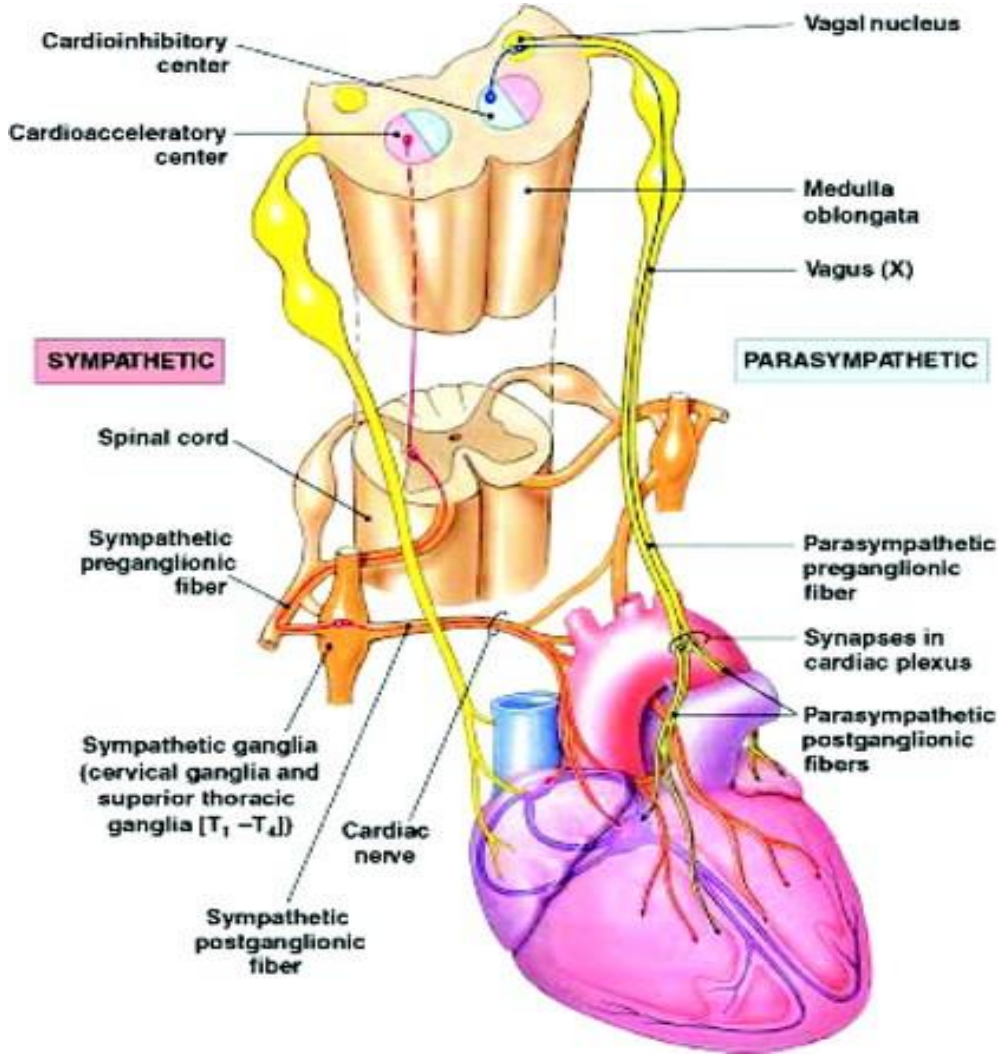
Lymphatics of the Heart

- **Begins:** by accompanying the coronary arteries and form two trunks.
- **Ends:**
  - The right trunk ends int eh brachiocephalic nodes
  - The left trunk ends in the tracheobronchial lymph nodes at the bifurcation of the trachea.



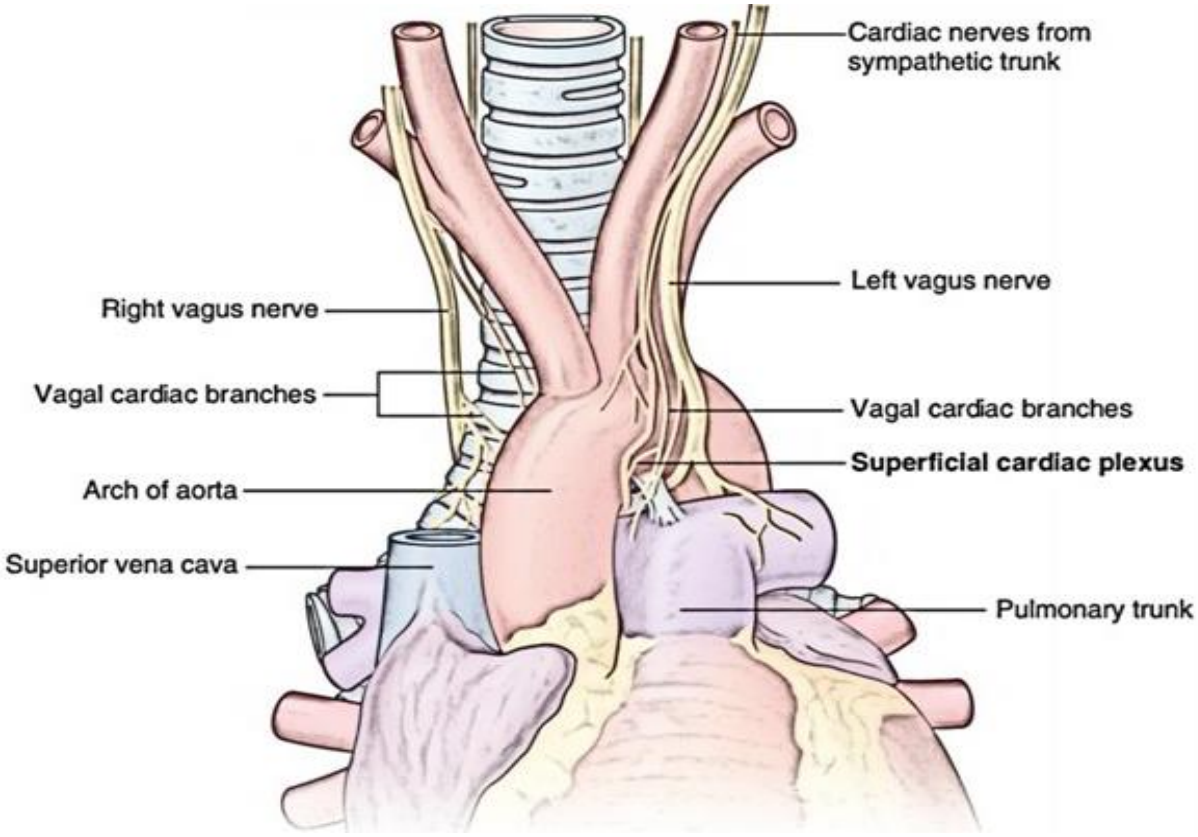
Nerve Supply of Heart

- **The Parasympathetic Nerves:**
  - They reach the heart via the vagus.
  - **Function:** act as cardioinhibitory, therefore on stimulation they slow down the heart rate.
- **The Sympathetic Nerves:**
  - Are derived from the upper 4-5 thoracic segments of the spinal cord.
  - **Function:** act as cardio-acceleratory, therefore on stimulation they increase the heart rate as well as dilate the coronary arteries.
- **Note:** both the sympathetic and parasympathetic nerves form the superficial and deep cardiac plexuses.



Cardiac Plexuses

	Superficial Cardiac Plexus	Deep Cardiac Plexus
Site:	Below the arch of the aorta and on the right side of ligamentum arteriosum.	Lies in-front of the tracheal bifurcation (deep to the arch of aorta)
Formation:	Formed by 2 autonomic nerves: • Superior cervical cardiac branch of left sympathetic chain • Inferior cervical cardiac branch of left vagus nerve	By all cardiac branches arising from the 2 sympathetic chains and vagi except the 2 branches which join the superficial plexus.
Branches:	**It gives branches to:** • The deep cardiac plexus • Right coronary artery to the heart • Left anterior pulmonary plexus in-front of left bronchus.	**It gives branches to:** • The right coronary plexus • The left coronary plex • The right anterior pulmonary plexus • The left anterior pulmonary plexus • The superficial cardiac plexus.



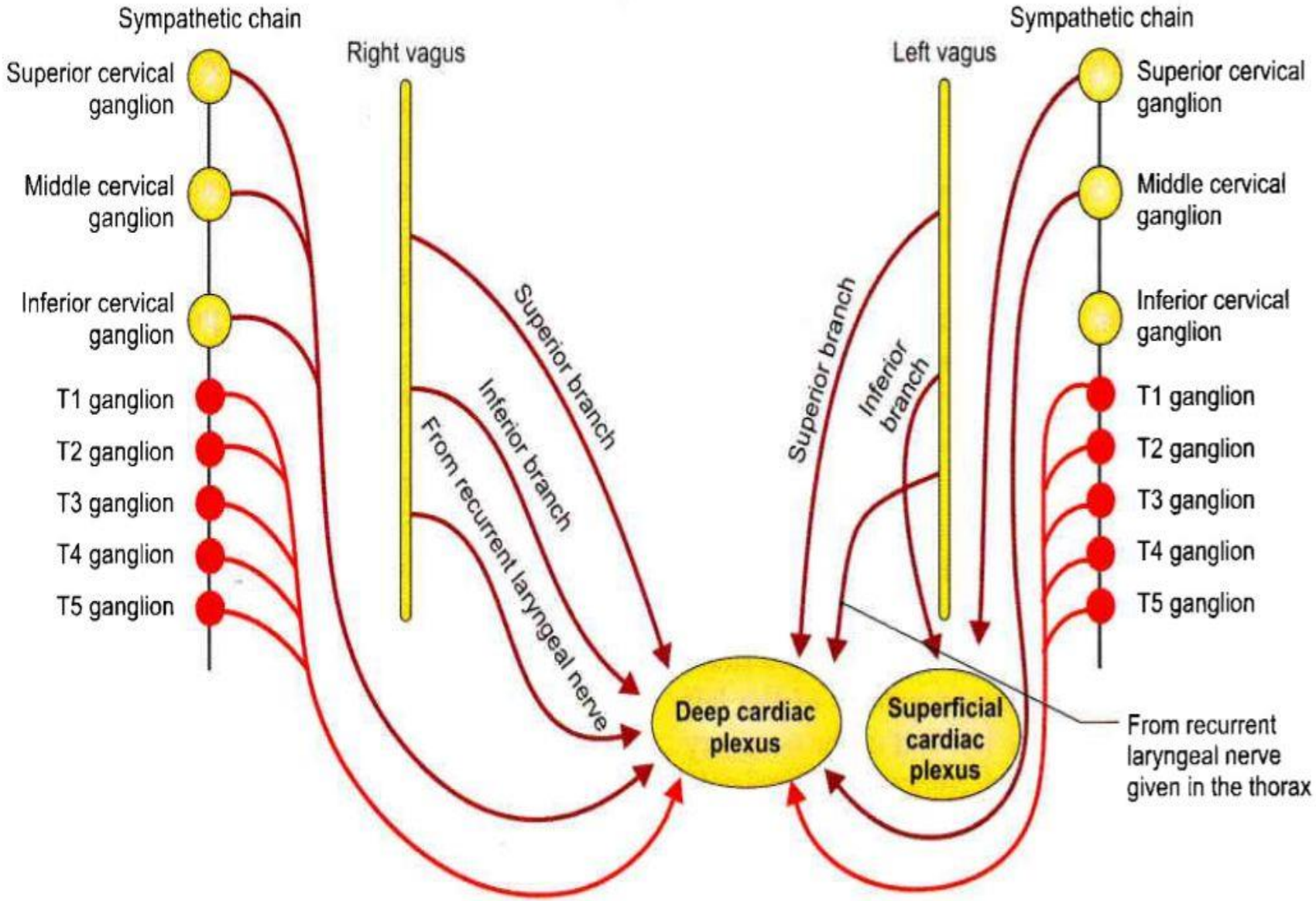
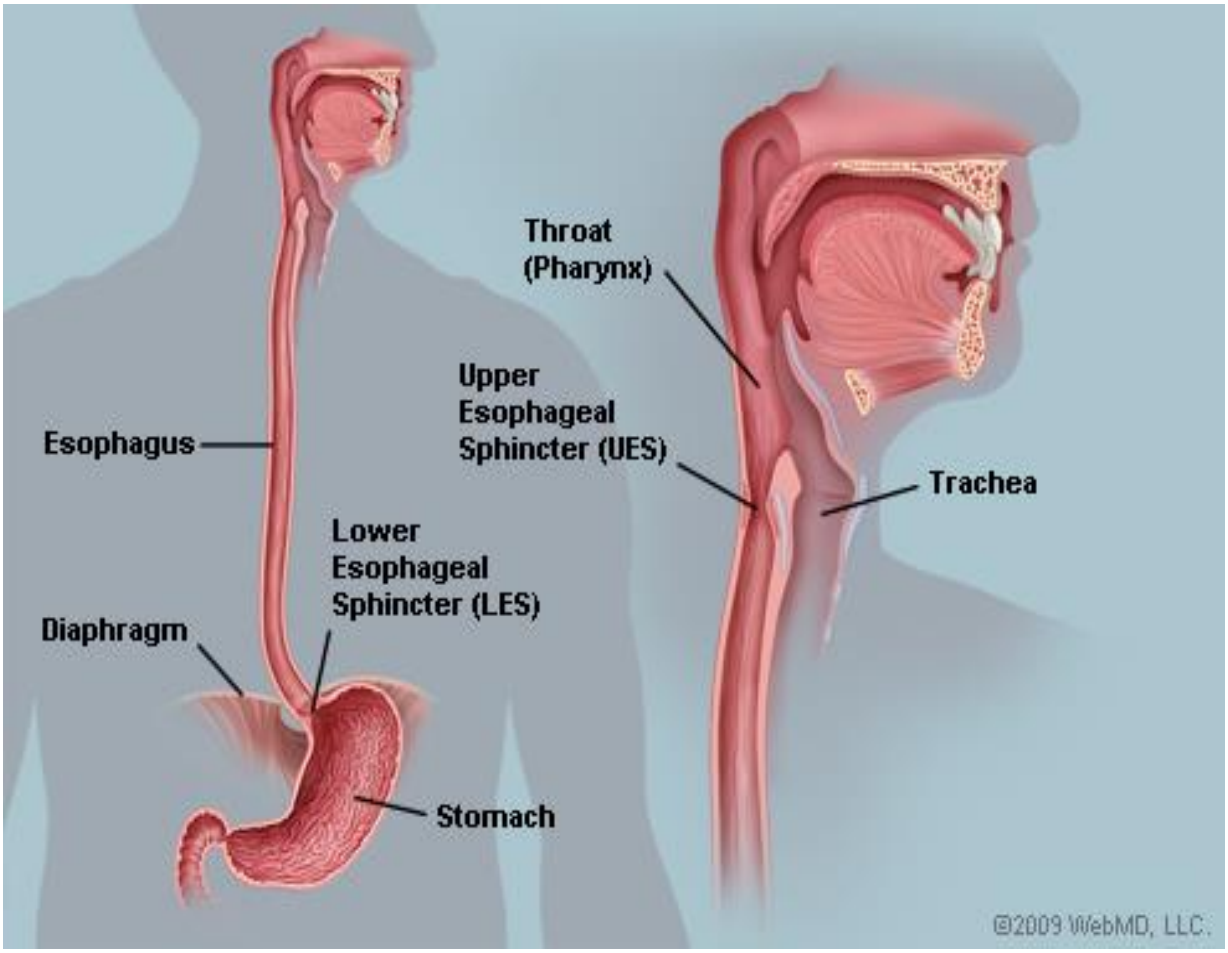


Fig. 18.30: Formation of superficial and deep cardiac plexuses

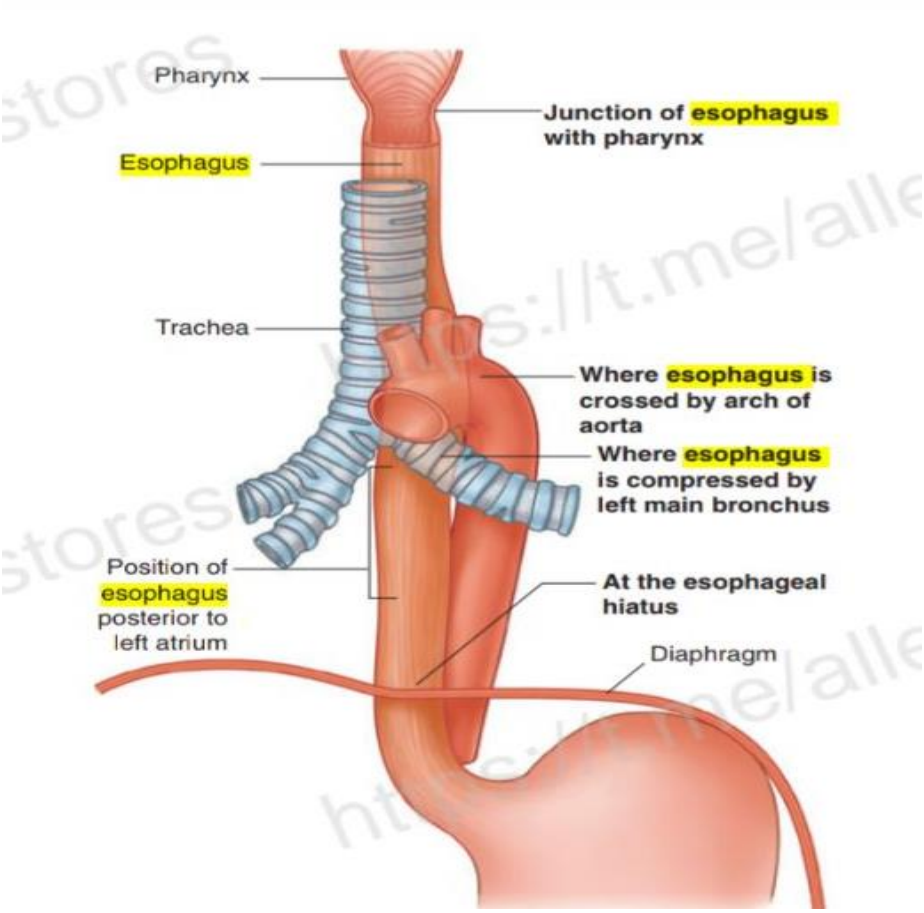
- **Clinical Anatomy of the Heart**
  - **Tachycardia**—increased heart rate.
  - **Bradycardia**—decreased heart rate.
  - **Arrhythmia**—irregular heart rate.
  - **Pericarditis**—inflammation of the pericardium.
  - **Myocarditis**—inflammation of the myocardium
  - **Endocarditis**—inflammation of the endocardium.
  - **Cor Pulmonale**—heart failure due to lung disease.
  - **Mitral Stenosis**—is narrowing of the valve orifice due to the fusion of the cusps.
    - **Note:** this can happen at all of the valves in the heart.
  - **Aortic Incompetence/regurgitation**—occurs when the valve orifice dilates, or the cusps stiffen leading to imperfect closure of the valve. This causes back flow of the blood.
  - **Cardiac Arrhythmias**—is caused by damage to the conducting system of the heart.

Esophagus

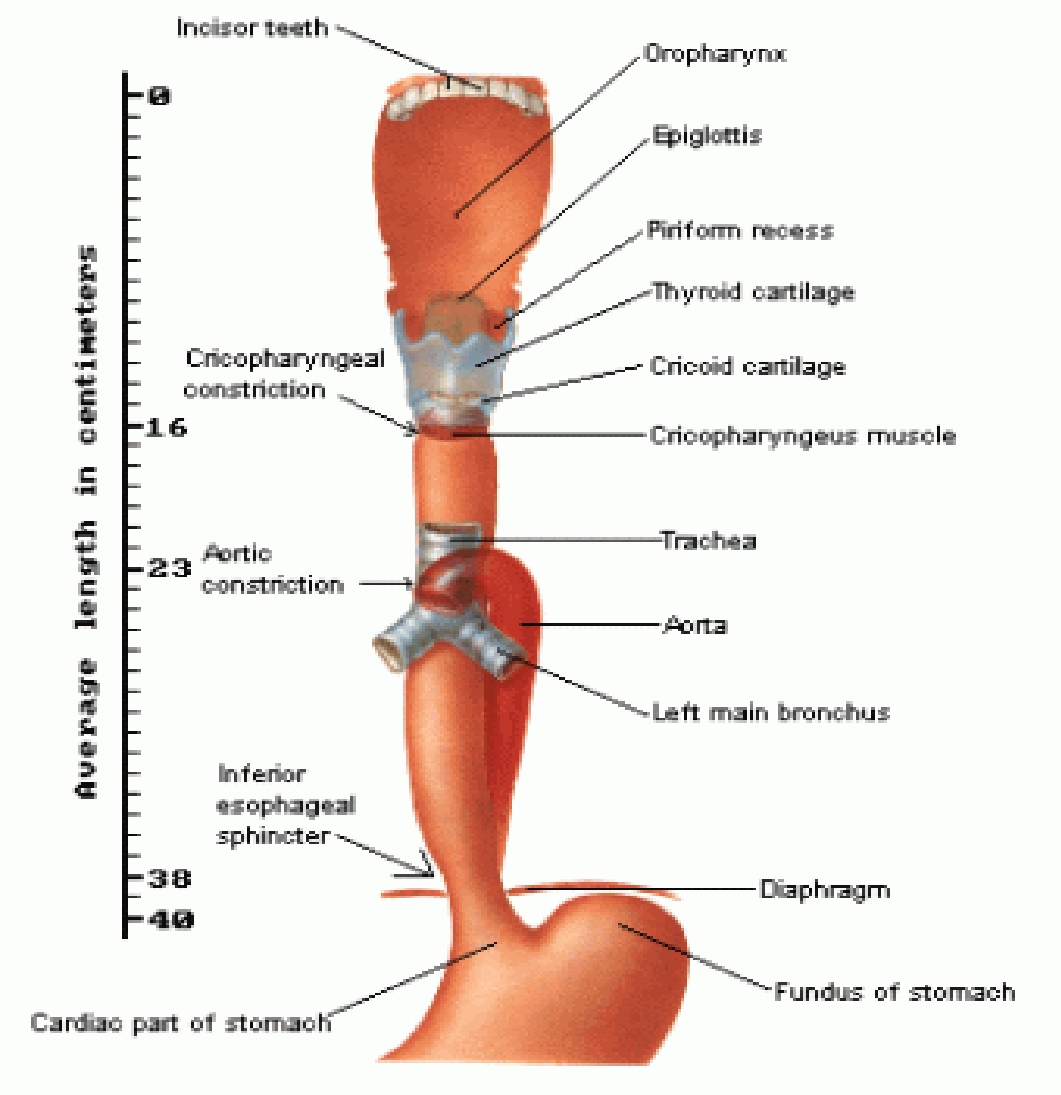


- **Definition:** it's a narrow muscular tube, that forms the passage for the food between the pharynx and stomach.
- **Function:** moves the food from the pharynx to the stomach through a process called peristalsis, which is rhythmic contraction of the muscles which allow the food to go down the esophagus.
- **Extension:** from the inferior border of cricoid cartilage at the 6th cervical vertebra (C6) to the cardiac orifice of the stomach at the 11th Thoracic vertebra (T11) piercing the diaphragm via the esophageal hiatus at T10.
- **Length:** 25cm/9.8 inches long

- **Sphincters:**
  - **Upper Esophageal Sphincter**—true anatomical sphincter
    - **Location:** at the junction between the pharynx and esophagus.
  - **Lower Esophageal Sphincter**—physiological sphincter
    - **Location:** at the junction between the stomach and esophagus (gastroesophageal junction).
      - **Note:** it's a physiological sphincter because there are no specific sphincter muscles present, instead it's maintained by four factors:
        1. The acute angle at which it enters the stomach.
        2. Intra-abdominal pressure
        3. Prominent mucosal folds
        4. Right crus of the diaphragm.


Pharynx
Junction of esophagus with pharynx
Esophagus
Trachea
Where esophagus is crossed by arch of aorta
Where esophagus is compressed by left main bronchus
Position of esophagus posterior to left atrium
At the esophageal hiatus
Diaphragm

- **Constrictions**
    - There are 4 physiological constriction in the lumen of the esophagus along its path. These constrictions can be remembered by the acronym “ABCD.”
        - **A**rch of Aorta
        - **B**ronchus (left)
        - **C**ricoid Cartilage and cricopharyngeal muscle
        - **D**iaphragmatic Hiatus



- **Blood Supply**
    - For descriptive purposes the esophagus will be divided into three parts:
        - Cervical part
        - Thorax part
        - Diaphragmic part

	Arterial Supply	Venous Drainage	Lymphatic Drainage
Cervical part	Inferior thyroid arteries	Brachiocephalic veins	Deep Cervical Nodes
Thoracic part	Esophageal branches of the aorta	Azygos Veins	Posterior Mediastinal Nodes
Abdominal part	Branches of the left gastric artery	Left gastric vein and vena azygos via hemiazygos vein.	Left Gastric Nodes

- **Note:** the lower end of the esophagus is one of the sites of portosystemic anastomoses.
- **Nerve Supply:**
    - **Sympathetic:**
        - Upper half of the esophagus is supplied by the fibers coming from the middle cervical ganglion and run with the inferior thyroid arteries.
        - Lower half of the esophagus is supplied by fibers coming directly from the upper four thoracic ganglia.
            - **Note:** these fibers form the esophageal plexus before supplying the esophagus.
    - **Parasympathetic:**
        - Upper half of the esophagus is supplied by the recurrent laryngeal nerves.
        - The lower half of the esophagus is supplied by the esophageal plexus that's formed mainly by the 2 vagi.

Esophageal Plexus	
Site	Lies around the esophagus
Formation	**Formed by:** • Parasympathetic fibers from the 2 vagi. • Sympathetic fibers from the upper 5 thoracic ganglia.
Supplies	The autonomic fibers to the esophagus.

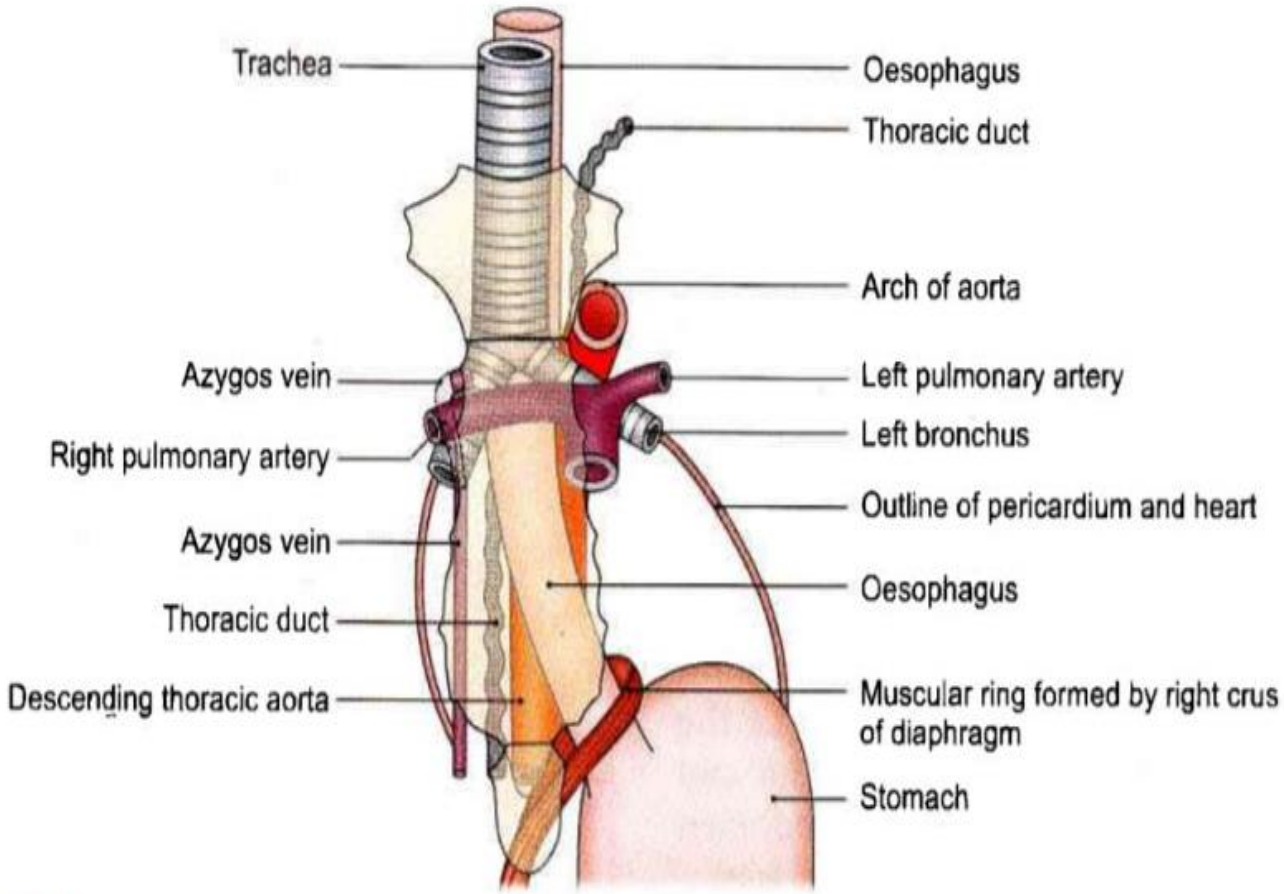
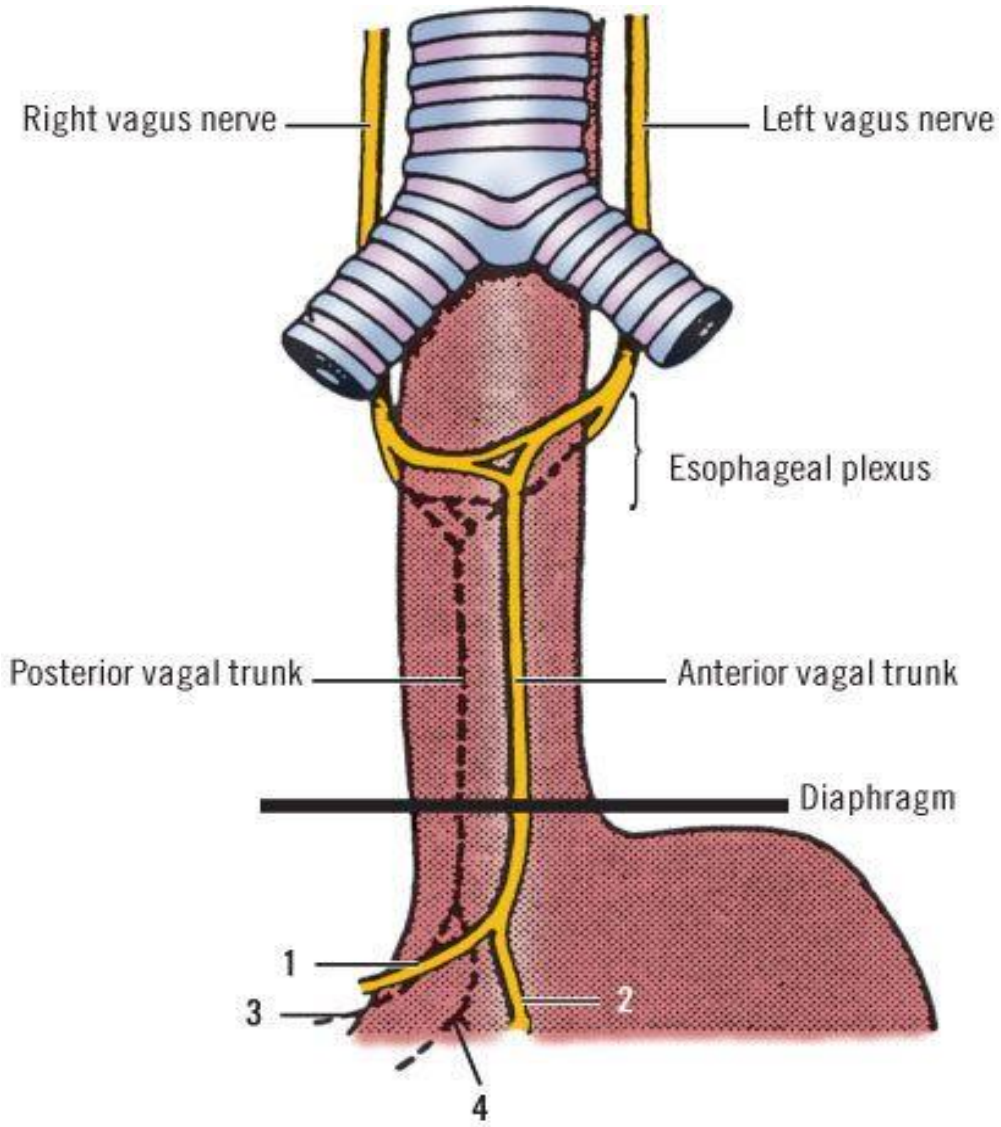


Fig. 20.4: Structures in the posterior mediastinum seen after removal of the heart and pericardium



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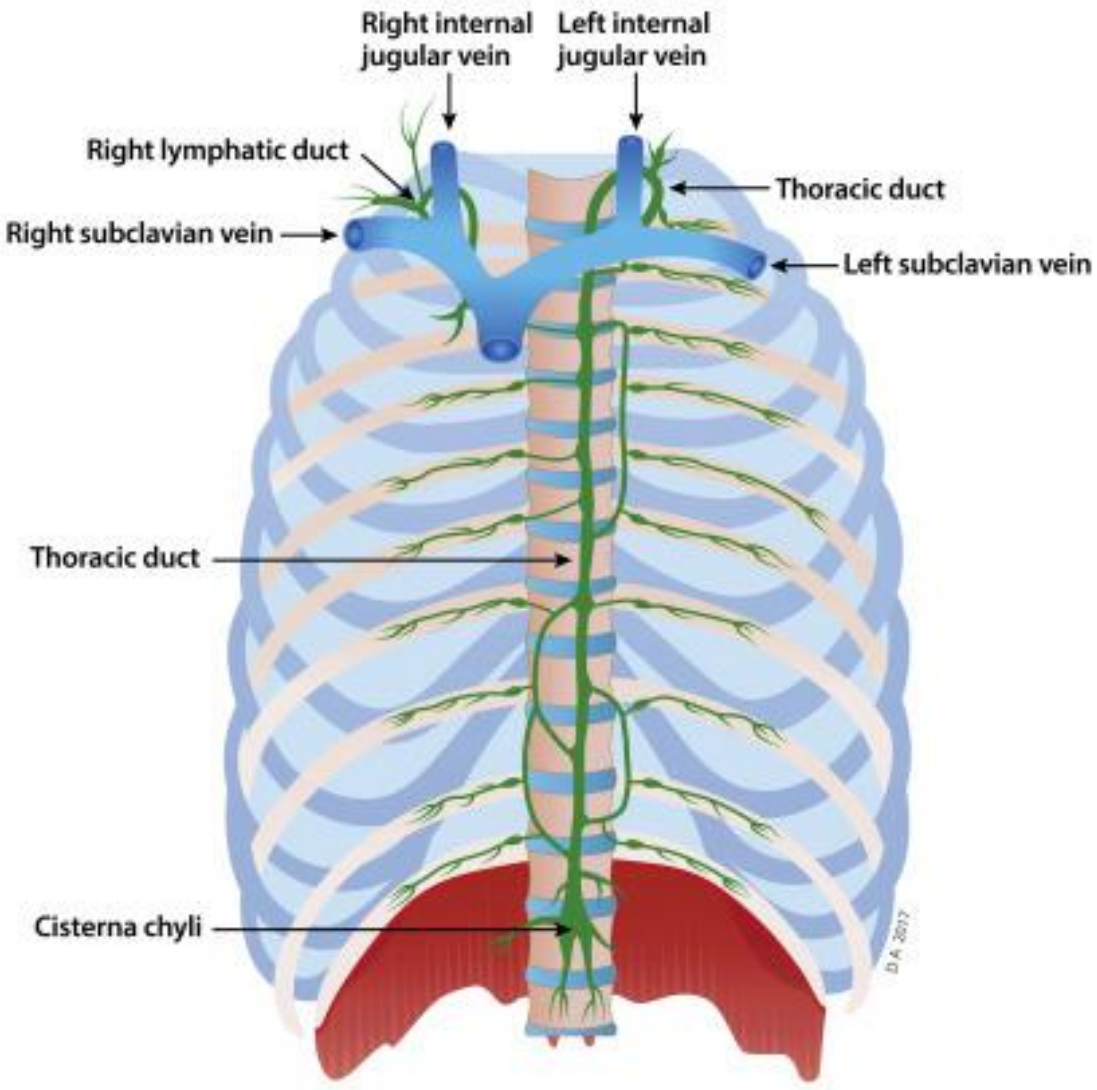
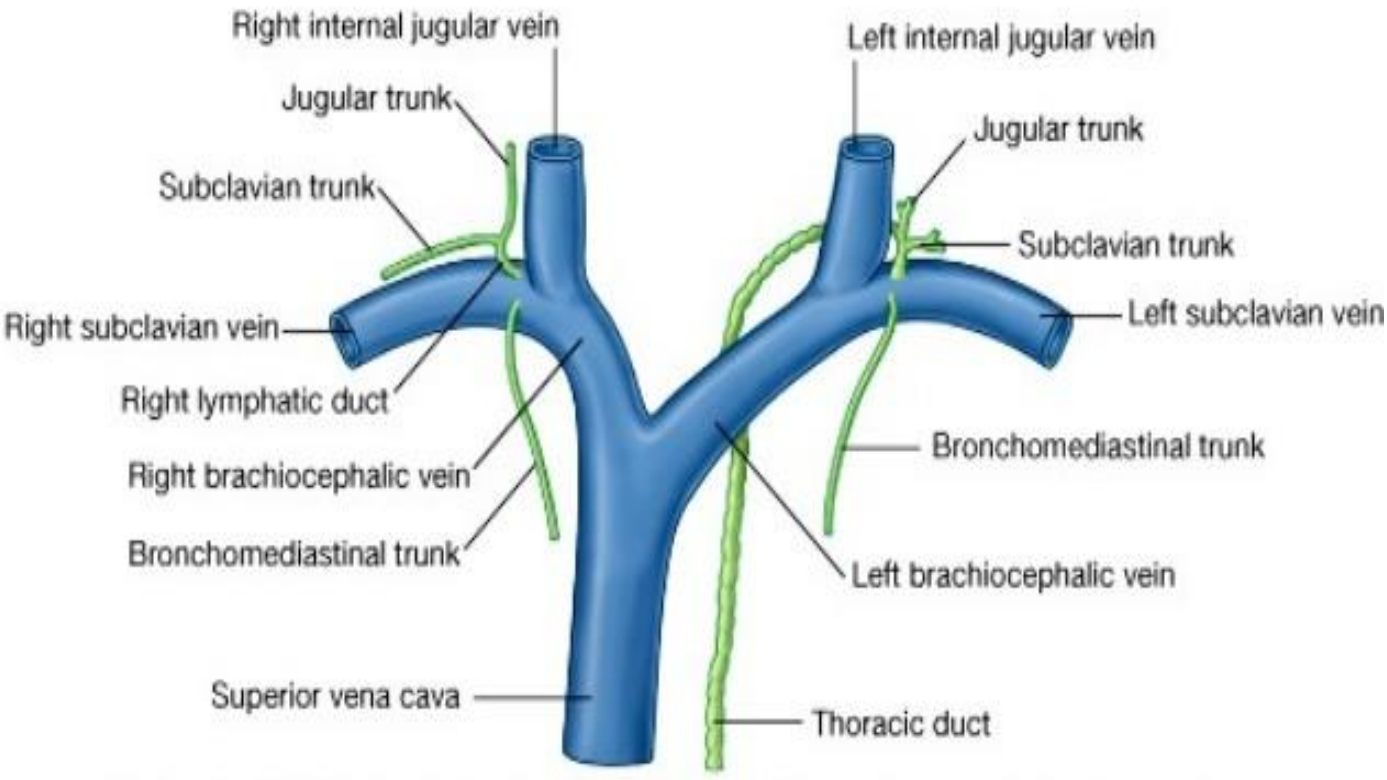
- **Clinical Anatomy:**
  - **Dysphagia**—occurs when there is difficulty of swallowing
  - **Achalasia Cardia**—which is the condition of neuromuscular incoordination which is characterized by the inability of the esophagus to dilate.
  - **Barrett's Esophagus**—which refers to metaplasia of the lower esophageal squamous epithelium to gastric columnar epithelium.
  - **Esophageal Carcinoma**—tumor of the esophagus.

Thoracic Duct

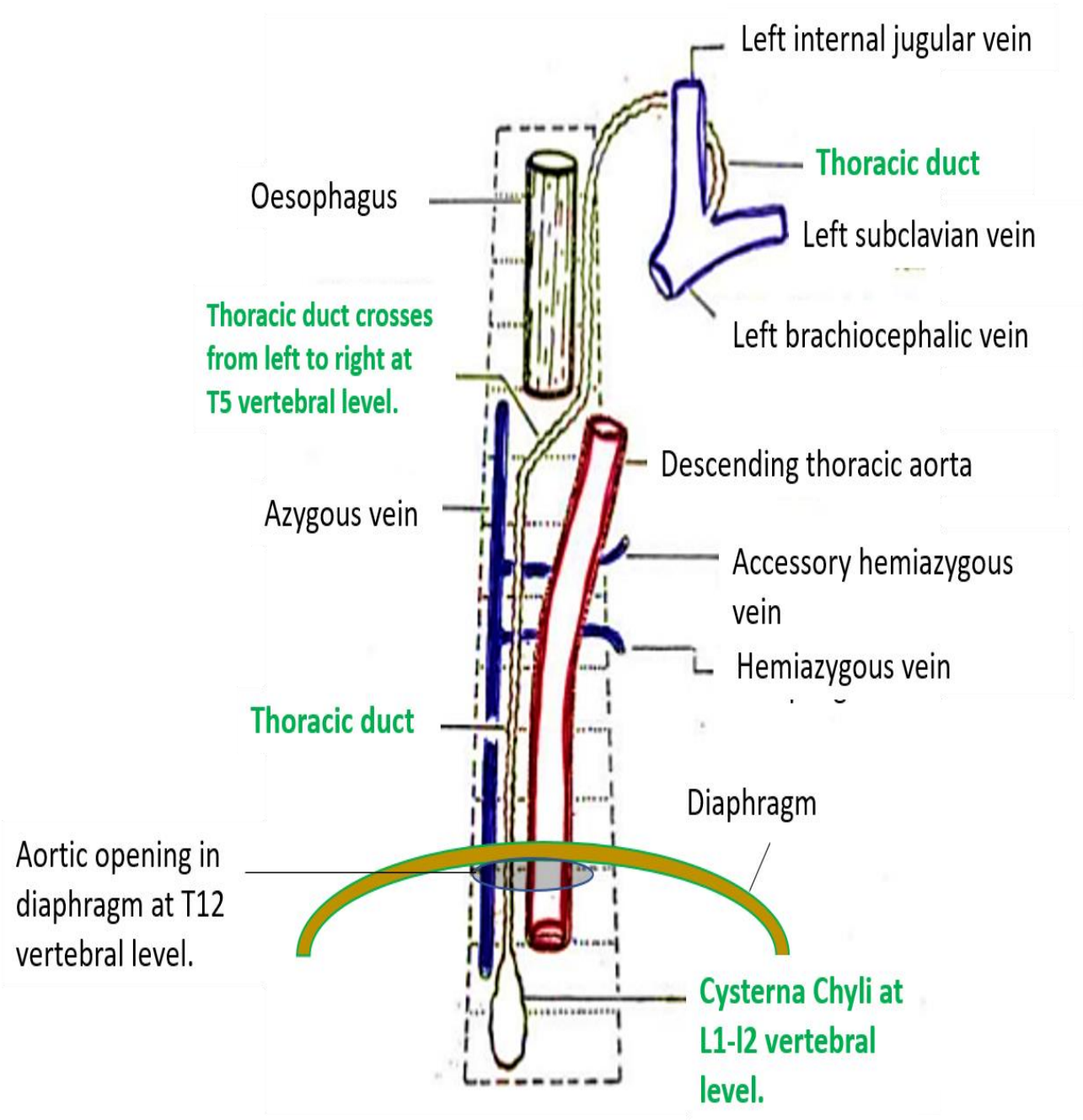


- **Definition:** it's the largest lymphatic vessel in the body.
- **Begins**: as a continuation of the upper end of the cisterna chyli near the lower border of the 12th thoracic vertebra.
    - Enters the thorax through the aortic opening of the diaphragm.
- **Ends:** by opening into the angle of junction between the left subclavian and left internal jugular veins.
- **Extension:** from the upper part of the abdomen to the lower part of the neck.
- **Length:** 45cm/18inches long.

- **Function:** it receives lymph from the whole body below the diaphragm and the left side/half above the diaphragm.
- **Tributaries:**
    - Posterior Mediastinal nodes
    - Small intercostal nodes
    - Left jugular trunk—formed by the efferent vessels at the root of the neck.
    - Left subclavian trunk—formed by the nodes int eh axilla.
    - Left Broncho-mediastinal trunk—drains lymph from the left half of the thorax.

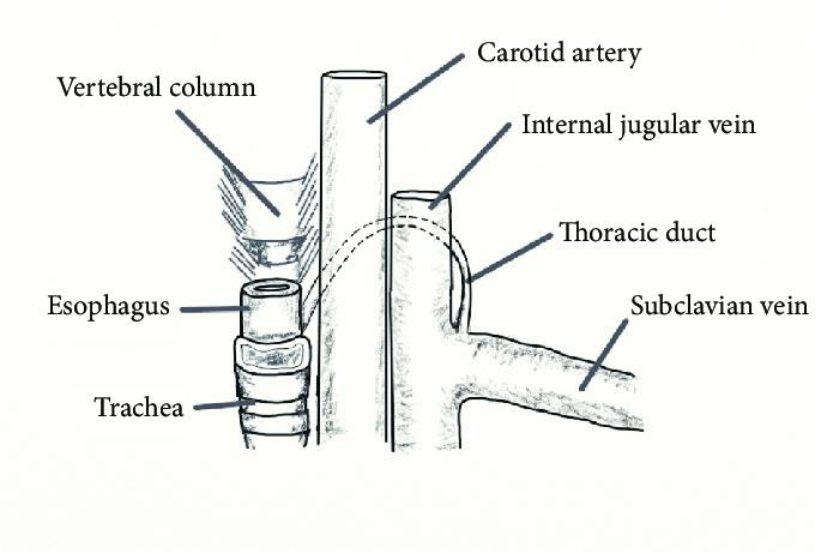


Course of Thoracic Duct

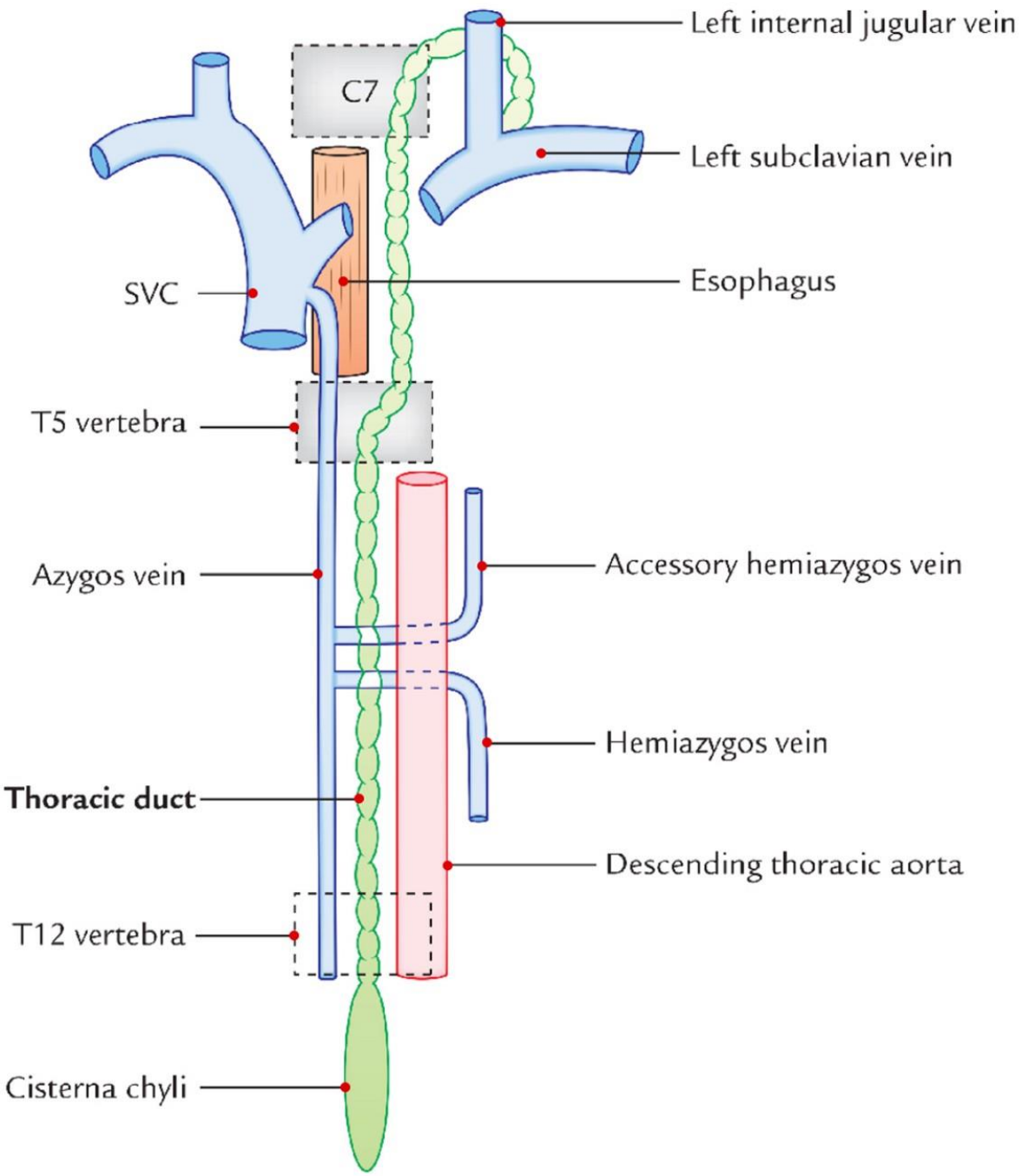


- **Relations:**
    - **In the Superior Mediastinum:**
        - ***Anteriorly:***
            - Arch of Aorta
            - Origin of the Left Subclavian Artery
        - ***Posteriorly:***
            - Vertebral Column
        - ***To the Right:***
            - Esophagus
        - ***To the Left:***
            - Pleura
    - **In the Posterior Mediastinum:**
        - ***Anteriorly:***
            - Diaphragm
            - Esophagus
            - Right Pleural Recess
        - ***Posteriorly:***
            - Vertebral Colum
            - Right Posterior Intercostal Arteries
            - Terminal Parts of the Hemiazygos Veins
        - ***To the Right:***
            - Azygos Vein
        - ***To the Left:***
            - Descending Thoracic Aorta

- **At the Aorta Opening of the Diaphragm:**
  - ***Anteriorly:***
    - Diaphragm
  - ***Posteriorly:***
    - Vertebral Column
  - ***To the Right:***
    - Azygos Vein
  - ***To the Left:***
    - Aorta



- **In the Neck**
  - ***Anteriorly:***
    - Left Common Carotid Artery
    - Left Vagus
    - Left Internal Jugular Vein
  - ***Posteriorly:***
    - Vertebral Artery and Vein
    - Sympathetic trunk
    - Thyrocervical trunk and its branches
    - Left Phrenic nerve
    - Medial border of the Scalenus Anterior muscle
    - The first part of the Left Subclavian Artery
      - Prevertebral Fascia covering all the structures mentioned.


Left internal jugular vein
C7
Left subclavian vein
SVC
Esophagus
T5 vertebra
Azygos vein
Accessory hemiazygos vein
Hemiazygos vein
Thoracic duct
Descending thoracic aorta
T12 vertebra
Cisterna chyli

Citation Page

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